POPULAR

ASTRONOMY.

He Stretcheth Out the North Over the Empty Place,
and Hangeth the Earth on Nothing.

PLAINLY WORDED AND LARGELY UNTECHNICAL IN LANGUAGE. AMPLY ILLUSTRATED.

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PLATE I.

Popular Astronomy.

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HISTORICAL EULOGY ON LAPLACE.

BY BARON FOURIER*

(Translated by T. J. J. See)

FOR POPULAR ASTRONOMY.

Gentlemen, the name of Laplace has resounded in all parts of the world where the sciences are honored; but his memory could not receive a more appropriate homage than the unanimous tribute of admiration and regret of the illustrious body in whose labors and glories he has shared. He has consecrated his life to the study of the greatest objects which can occupy the human mind.

The wonders of the heavens, the profound questions of natural philosophy, the ingenious and subtle combinations of mathematical analysis, all the laws of the universe, have been presented to his mind for nearly sixty years, and his efforts have been crowned by immortal discoveries.

It was observed from his earliest studies that he was endowed with a prodigious memory; for him all intellectual occupations were easy. He rapidly acquired a very extensive knowledge of the ancient languages, and cultivated diverse branches in literature. Everything interests the born genius, everything can reveal it. His first successes were in theological studies; he treated with talent and extraordinary sagacity the most difficult points of controversy. We do not know by what fortunate circumstance Laplace passed from scholasticism to sublime geometry. This last science which admits of no division attracted and fixed his attention. From that time he abandoned himself without reserve to the impulses of his genius, and perceived clearly that a sojourn at the capital had become to him a necesity. D'Alembert was then enjoying all the splendor of his renown. It fell to his lot to inform the Court of Turin that its Royal Academy possessed a mathematician of the first order, Lagrange, who, by default of this noble recognition, had been compelled to remain long ignored. D'Alembert had announced to the King of Prussia

* Delivered in the public session of the Royal Academy of Sciences, June 15, 1829.

that only one man in Europe could replace at Berlin the illustrious Euler, who, recalled by the Russian Government, consented to return to St. Petersburg. I find, in the unpublished letters in possession of the Institute of France, the details of this glorious negotiation which fixed Lagrange in residence at Berlin. About the same time Laplace began that long career which he was soon to distinguish.

He presented himself to D'Alembert, preceded by numerous recommendations which were believed to be very powerful. But his attempts proved unsuccessful; he was not even introduced. Then he addressed to the one whose support he solicited a very remarkable letter on the general principles of mechanics, of which M. Laplace has several times shown me diverse fragments. It was impossible that so great a geometer as D'Alembert could fail to be struck by the singular profundity of this writing. The same day he summoned the author of the letter, and said to him, in his own words: "Sir, you see that I attach little importance to recommendations; you have no need for them; you have made yourself better known; this satisfies me; my support is due you."

A few days later he caused Laplace to be nominated Professor of Mathematics at the Military School of Paris. From this time on, devoted exclusively to the science which he had chosen, he gave to his work a fixed and never-deviating direction; for imperturbable constancy of purpose has always been the principal trait of his genius. He touched already the known limits of mathematical analysis, he possessed all that was ingenious and powerful in this science at the time, and no one was more capable than he to extend its domain. He had solved a leading question of theoretical astronomy. He formed the project of consecrating his life to this sublime science; he was destined to perfect it, and able to comprehend it in all its extent. He meditated profoundly his glorious design; he has spent his whole life in accomplishing it with a perseverance which is perhaps unexampled in the history of the sciences.

The immensity of the subject flattered the just pride of his genius. He undertook to compose the *Almagest* of his age, a monument which he has left us under the name of the *Mécanique Céleste*; and his immortal work transcends that of Ptolemy as much as the analysis of the moderns surpasses the elements of Euclid. Time, which alone justly dispenses literary glory, which consigns to oblivion all contemporaneous mediocrities, perpetuates the memory of great works. These alone transmit to posterity the character of each century. Thus will the name of

Laplace live through all ages. But I hasten to remark that enlightened and faithful history will not separate his memory from that of the other successors of Newton. It will associate the illustrious names of D'Alembert, of Clairaut, of Euler, of Lagrange and of Laplace. I restrict myself here to citing the great geometers whom the sciences have lost, and whose researches have had for a common aim the perfection of physical astronomy. To give a correct idea of their works it is necessary to compare them; but space obliges me to reserve a portion of this discussion for our memoirs.

Next to Euler, Lagrange has contributed most to the founding of mathematical analysis. In the writings of these two great geometers it has become a distinct science which alone of mathematical theories can be said to be completely and rigorously demonstrated. It alone among all these theories is sufficient in itself and throws light upon all the rest; to them it is so necessary, that, deprived of its aid, they could very imperfectly exist.

Lagrange was born to invent and to extend all the sciences of analysis. In whatever condition fortune might have placed him, whether peasant or prince, he would have been a great geometer; he would necessarily have done it and without any effort; the same cannot be said of all who have excelled in this science, even in the first ranks. Had Lagrange been a contemporary of Archimedes and of Conon, he would have divided the glory of the most memorable discoveries. At Alexandria he would have been a rival of Diophantus.

The distinctive trait of his genius consists in the unity and grandeur of his views. He always fixes attention on an idea which is simple, just and very exalted. His principal work, the *Mécanique Analytique*, might be named the *Mécanique Philosophique*; for he reduced all the laws of equilibrium and of motion to a single principle; and what is not less admirable he subjected them to a single analytical method of which he himself was the inventor. All his mathematical compositions are remarkable for symmetry of form, generality of method, and, if we may so speak, for perfection of analytical style.

Lagrange was no less a philosopher than a great geometer. He proved this through the whole course of his life by the moderation of his desires, his immutable attachment to the general interests of humanity, by the noble simplicity of his manners and elevation of character, and finally by the fitness and profundity of his scientific works.

Laplace had received from nature all the force of genius which

an immense enterprise could exact. Not only has he collected in his *Almagest of the 18th Century* what the mathematical and physical sciences had already invented, and which constitute the foundation of astronomy; but he added to this science capital discoveries of his own which had escaped all of his predecessors.

He has solved, either by his own methods or by those whose principles Euler and Lagrange have pointed out, the most important and certainly the most difficult of all the problems which have been considered before him. His constancy triumphed over all obstacles. When his first efforts were not successful he renewed them under the most ingenious and the most diverse forms.

Thus there was observed in the motion of the Moon an acceleration whose cause could not be discovered. It had been held that this effect could arise from the resistance of the ethereal medium where the heavenly bodies move. If this were true, the same cause, affecting the course of the planets, would tend to change little by little the primitive order. These bodies would be incessantly disturbed in their courses and finally precipitated on the mass of the Sun. It would be necessary that the creative power intervene anew to prevent or to repair the immense disorder which the lapse of time would produce.

This cosmological question is assuredly one of the greatest which the human intelligence can propose; today it is solved. The first researches of Laplace upon the invariability of the dimensions of the solar system and his explanation of the secular equation of the Moon, have led to this solution.

He first examined if the acceleration of the lunar motion could be explained by supposing that the action of gravity is not instantaneous but subject to successive transmissions like light. From this point of view he could not discover the true cause. Finally a new research served his genius better. On March 19th, 1787, he presented to the Academy of Sciences a clear solution free from this capital difficulty. He proved very distinctly that the observed acceleration is a necessary effect of universal gravitation.

This great discovery subsequently cleared up the most important points of the system of the world. As a result the same theory shows that, if the action of gravitation upon the heavenly bodies is not instantaneous, we must suppose that it is propagated more than fifty million times faster than light, whose velocity is well known to be seventy thousand leagues per second. He further concluded from his theory of the Moon's motion that

the medium in which the heavenly bodies move offers to the course of the planets a resistance which is practically insensible; for this cause would effect especially the motion of the Moon, and here the effect produced could not be observed.

The discussion of the motion of this body is rich in remarkable results. We conclude from it, for example, that the rotatory motion of the Earth on its axis is invariable. The length of the day has not changed one-hundredth part of a second during two thousand years. It is remarkable that an astronomer would have no need to leave his Observatory to measure the distance from the Earth to the Sun. It suffices for him to observe closely the variation of the lunar motion; from this he could conclude the distance with certainty.

A consequence still more striking is that which relates to the figure of the Earth; for even the form of the terrestrial globe is impressed upon certain inequalities of the course of the Moon. These inequalities would not exist if the Earth were perfectly spherical. We can determine the amount of terrestrial flattening by observation of the lunar motions alone and the results deduced from it agree with the actual measures yielded by the great geodetic voyages to the equator, in the northern regions, in India and numerous other countries. It is to Laplace above all others that we owe this astonishing perfection of modern theories.

I cannot here undertake to indicate his works one after another and the discoveries to which they have led.

This enumeration alone, however brief it might be, would exceed the limits which I was compelled to prescribe for myself. Besides his researches on the secular equation of the Moon, and the no less difficult and no less important discovery of the long inequality of Jupiter and Saturn, we could cite his admirable theorems on the libration of Jupiter's satellites. We should mention his analytic treatment of the tides of the sea, and show the immense extension he has given this subject.

There is no important point of physical astronomy which was not for him an object of study and profound discussion; he subjected to calculation the greater part of the physical conditions which his predecessors had omitted. In the already very complex question of the form and the rotatory motion of the Earth, he considered the effect of the presence of water distributed between the continents, the compression of the interior layers and the secular diminution of the dimensions of the globe.

In this collection of researches we should notice especially those which relate to the stability of great phenomena: no object is

more worthy of the meditation of philosophers. Thus we have recognized that the causes, either accidental or constant, which disturb the equilibrium of the oceans are subjected to limits which cannot be passed. The specific gravity of water being much less than that of the solid Earth it follows that the oscillations of the ocean are always confined between very narrow limits; which would not be the case if the liquid spread over the globe were of much greater density. In general nature holds in reserve conservative and ever-present forces which act as soon as the trouble begins and augment in proportion as the disturbance is greater. They quickly re-establish the accustomed order. We find in all parts of the universe this preservative power. The forms of the great planetary orbits and their inclinations vary and oscillate in the course of ages; but these changes are limited. The principal dimensions are maintained and this immense assemblage of heavenly bodies oscillates about a mean position toward which it is always carried. Everything is adjusted for order, perpetuity and harmony.

In the primitive and liquid state of the terrestial globe, the heaviest matter settled towards the center; and this condition has determined the stability of the sea.

Whatever may have been the physical cause of the formation of the planets, it imparted to all the bodies a projectile motion in a common direction about an immense globe; in this way the solar system has been rendered stable. The same effect is produced in the systems of satellites and of rings. Order is there maintained by the power of the central mass. Hence, there is not, as Newton himself and Euler had suspected, an adventitious force which should one day repair or prevent the disturbance which time had wrought. This is the law of gravitation itself, which rules all, is sufficient for all, and maintains order and variety. Having proceeded once only from supreme wisdom, it has presided since the origin of time and renders all disorder impossible. Newton and Euler did not yet recognize all the perfections of the universe. In general whenever any doubt had arisen in regard to the exactness of the Newtonian law, and, for the explanation of apparent irregularities, we have proposed the accession of a foreign cause, it has always happened, after a profound examination, that the original law has been verified. It explains to-day all known phenomena. The more precise the observations the better do they conform to theory. Of all the great mathematicians, Laplace is the one who has penetrated most profoundly these great questions; he has, so to speak, settled them.

We cannot affirm that it was given to him to create an entirely new science as did Archimedes and Galileo; to give to mathematical theories original and immensely extended principles, as did Descartes, Newton and Leibnitz; or like Newton to transfer for the first time to the heavens and to extend throughout the universe the terrestrial dynamics of Galileo; but Laplace was born to perfect all, to penetrate everything, to extend all limits, to solve what was believed to be insoluble. He would have completed the science of the skies, if this science could be completed.

We find this same character in his researches on the analysis of probability, a science entirely modern and of immense extent, whose object, often misconceived, has given rise to the most erroneous interpretations, but whose applications will one day embrace the whole domain of human knowledge, a happy supplement to the imperfection of our nature. This art arose from a single trait of the clear and prolific genius of Pascal; it has been cultivated, since its origin, by Fermat and Huyghens. A philosophical geometer, John Bernouilli, was its principal founder.

A singularly happy discovery of Stirling, the researches of Euler, and above all an ingenious and important application due to Lagrange, have perfected this doctrine; it was cleared up by the objections of D'Alembert and by the philosophical views of Condorcet: Laplace collected and fixed its principles. It has become a new science of prodigious extent, subject to a single analytical method. Fruitful in ordinary applications, it will one day illuminate every branch of natural philosophy. If it is permissible to express here a personal opinion we shall add that the solution of one of the principal problems, which the illustrious author has treated in the tenth chapter of his work, does not appear to be exact; and yet considered in its totality this work is one of the most precious monuments of his genius.

After having cited such brilliant discoveries it would be useless to add that Laplace belonged to all the great academies of Europe. I could, and perhaps ought, to recall also the high political dignities with which he was clothed; but this enumeration would belong only indirectly to the object of this discourse. It is the great mathematician whose memory we celebrate. We have separated the immortal author of the *Mécanique Céleste* from all the accidental facts which concern neither his glory nor his genius.

Indeed, gentlemen, of what concern is it to posterity, who will have so many other details to forget, whether Laplace was at one time minister of a great nation? What concerns us most are

the eternal truths he discovered; these are the immutable laws of the stability of the world, and not the rank which he occupied some years in the senate called conservator. What concerns us, gentlemen, perhaps still more than his discoveries, is the example which he set to all those to whom the sciences are dear; it is the spirit of this incomparable perseverence which has sustained, directed and crowned so many glorious efforts.

I shall therefore omit the accidental circumstances and, so to speak, fortuitous incidents, particulars which have no relation to the perfection of his works. But I may say that in the first body of the state, the memory of Laplace was celebrated by an eloquent and friendly voice, which important services rendered to the historical sciences, to letters and to the state have for a long time distinguished.* I shall recall especially that literary ceremony which attracted the attention of the Capital. The French Academy, concurring in its recognition with the acclamations of the country decided that it would acquire a new glory in crowning triumphs of eloquence and of political virtue.† At the same time it chose to return as a successor of Laplace an academician illustrious for more than a title, who united in literature, in history, in public administration, all the qualities of superiority.‡

Laplace enjoyed an advantage which fortune has not always accorded to great men. From his early youth he was deservedly appreciated by illustrious friends. We have in hand some letters, still un-edited, which show us all the zeal with which D'Alembert introduced him to the military school of Paris, to prepare for him, if that were necessary, a better position at Berlin. President Bochard de Saron printed his first works. All the testimonials of friendship which were given him recall his great works and his great discoveries; but nothing could contribute more to the progress of all physical knowledge, than his relations with the illustrious Lavoisier, whose name, consecrated in the history of the sciences, has become an enduring object of respect and grief.

These two celebrated men united their efforts. They undertook and carried out very extended researches for measuring one of the most important elements in the physical theory of heat. They made also, about the same time, a long series of experiments on the dilatation of solids. The works of Newton have made sufficiently known the value which this great mathematician at-

* The Marquis de Pastoret.
† M. Royer-Collart.
‡ The Count Daru.

tached to the special study of the physical sciences. Laplace is, of all his successors, the one who has made the greatest use of his experimental method; he was almost as great a physicist as a geometer. His researches on refraction, on capillarity, barometric measures, on static properties of electricity, velocity of sound, molecular actions, properties of gases, attest that nothing in the investigation of nature could be foreign to him. He always desired especially the perfection of instruments; he caused to be constructed, at his own expense, by a celebrated artisan, a very precise astronomical instrument and has given it to the Observatory of France.

All kinds of phenomena were perfectly known to him. He was connected by an old friendship with two celebrated physicists whose discoveries have thrown light on all the arts and all the theories of chemistry. History will connect the names of Berthollet and Chaptal with that of Laplace. He liked to associate with them and their conferences have always had for an object and end the increase of knowledge most important and most difficult to acquire. The gardens of Berthollet at his house d'Arcueil were not separated from those of Laplace. Great memories and great sorrows have distinguished this enclosure. It was here that Laplace received celebrated strangers, influential men, from whom the sciences had received or might expect benefactions, but, especially those who were drawn by sincere zeal to the sanctuary of the sciences. Some were just commencing their careers, others would soon bring theirs to a close. He entertained them with extreme politeness. He even carried it so far that he allowed those who did not yet know of the full extent of his genius to believe that he might himself gain knowledge from their conversations.

In citing the mathematical works of Laplace we ought especially to point out the depth of his researches and the importance of his discoveries. His works are moreover, distinguished by another quality which all readers have appreciated. I refer to the literary merits of his compositions. The work entitled *Système du Monde* is remarkable for elegant simplicity of style, and for purity of language. There was no other example of this species of production; but we could form of it an approximate idea if we remember that it is possible to acquire a knowledge of the phenomena of the heavens in agreeable writings. The suppression of the signs required in the calculus can not contribute to clearness or render the reading easier. The work is a perfectly regular exposition of the results of profound study; it is an in-

genious resumé of the principal discoveries. The precision of style, the choice of methods, the grandeur of the subject, give a singular interest to this vast picture; but its real utility is to recall to geometers theorems whose demonstrations are known to them. Properly speaking it is a condensation of the material of a mathematical treatise.

The purely historical works of Laplace have a different object. They present to geometers with admirable talent the march of the human mind in the discovery of the sciences. Consequently the most abstract theories have a beauty of expression which is all their own; the same thing is observed in several treatises of Decartes, in certain pages of Galileo, of Newton, and of Lagrange. The novelty of the views, the elevation of thought, their relations to the great objects of nature, charm and fill the mind. It suffices that the style be pure and of a noble simplicity; such is the kind of literature which Laplace has chosen, and it is certain that he has here gained a place in the first rank. If he wrote the history of great astronomical discoveries, it became a model of elegance and of precision. No principal feature escaped him; his expression is neither obscure nor pretentious. All that he called great is great indeed; all that he omitted did not deserve to be cited.

M. Laplace preserved to a very advanced age that extraordinary memory which was the subject of remark in his earliest years; a precious gift which is not genius but which serves it to acquire and to retain. He never cultivated the fine arts, but he appreciated them. He was fond of Italian music and of the verses of Racine, and often took pleasure in reciting from memory various passages from this great poet. Paintings of Raphael ornamented his apartments. They were to be found by the side of the portraits of Descartes, of Francois Viète, of Newton, of Galileo, and of Euler.

Laplace always had the habit of taking very light nourishment; he diminished the quantity more and more even to excess. His very delicate eye-sight required continual precautions; but he managed to preserve it without alteration. These precautions for himself had but a single aim, that of reserving all his time and all his energy for intellectual work. He lived for the sciences; the sciences have rendered his memory eternal.

He contracted the habit of excessive concentration of thought, so injurious to the health, so necessary to profound study; and yet he underwent a sensible weakening only in the last two years of his life. At the commencement of the disease to which he suc-

cumbed there was noticed with alarm a symptom of delirium. The sciences occupied him still. He spoke with an unaccustomed ardor of the motions of the stars, and then of an experiment in physics, which he said was capital, announcing to the persons whom he believed to be present that he would soon entertain the Academy with these questions. His strength left him little by little. His physician*, who merited all his confidence by superior talents and by the care which friendship alone could inspire, watched near his bed. M. Bouvard, his co-worker and friend, never left him for an instant. Surrounded by a beloved family, under the eyes of a wife whose devotion had aided in supporting the sorrows inseparable from life, whose amenities and graces had made known to him the prize of domestic happiness, he received from his son, M. Marquis de Laplace, express testimonials of the most touching devotion. He gave signs of gratitude for the repeated tokens of interest shown him by the King and the Dauphin. The persons who assisted at his last moments recalled to him the titles of his glory and his brilliant discoveries. He answered: "That which we know is little, that of which we are ignorant is immense." This at least is, so for as we have been able to ascertain, the sense of his last words, which were spoken with difficulty. Moreover, we have often heard him express these thoughts and almost in the same terms. He passed away without pain. His supreme moment had arrived; the powerful spirit which had long animated him separated from the mortal envelope and returned to the skies.

The name of Laplace honors one of our provinces already prolific in great men, ancient Normandy.

He was born March 23, 1749; he died in his seventy-eighth year, May 5th, 1827, at nine o'clock in the morning.

I shall recall to you, gentlemen, the sad gloom which spread over this palace like a cloud when the new fatality was announced. This was the day and the hour of your accustomed meeting. Each of you maintained a mournful silence; each felt the sad blow with which the sciences had been smitten. Every respect was shown in this place which he had so long occupied among you. One thought only was present; all other meditation had become impossible. You adjourned with a unanimous resolution, and this time only were your usual labors interrupted.

It is undoubtedly beautiful, it is glorious, it is worthy of a powerful nation, to ordain brilliant honors to the memory of its celebrated men. In the country of Newton the chiefs of state

* M. Magendie.

wished to have the mortal remains of this great man solemnly interred among the royal tombs. France and Europe have offered to the memory of Laplace an expression of their grief less showy doubtless, but perhaps more touching and more true.

He has received an unaccustomed homage; he received it from his own people, in the midst of a learned company which alone could appreciate all of his genius. The voice of the weeping sciences has made itself audible in every country of the world where philosophy has penetrated. We have in hand much correspondence from all parts of Germany, England, Italy, New Holland, the English possessions in India, the two Americas; and we find everywhere the same sentiments of admiration and of regret. Certainly this universal lamentation of the sciences, so nobly and so freely expressed, has no less truth and splendor than the sepulchral pomp of Westminster.

Let me be permitted, before closing this discourse, to reproduce here a thought which presented itself when I recalled in this place the great discoveries of Herschel, but which is applicable still more directly to those of Laplace.

Your successors, gentlemen, will witness the accomplishment of the great phenomena whose laws he discovered. They will observe in the motions of the Moon the changes which he predicted and of which he alone was able to assign the cause. The continual observation of Jupiter's satellites will perpetuate the memory of the inventor of the theorems which govern them in their courses. The great inequality of Jupiter and Saturn, running through their long periods, and giving to these bodies new situations will recall without ceasing one of his most astonishing discoveries. These are the titles of a true glory which nothing can extinguish. The spectacle of the heavens will be changed, but at these remote epochs the glory of the inventor will continue forever; the traces of his genius bear the seal of immortality.

I have presented to you, gentlemen, some characteristics of an illustrious life consecrated to the glory of the sciences; may your memories supplement my feeble language! May the voice of our country, may that of all humanity rise to celebrate the benefactors of nations, the only homage worthy of those who have been able, like Laplace, to enlarge the domain of thought, and bear witness to man of the dignity of his being, by unveiling to our contemplation all the majesty of the heavens!

PLATE II.

N.

W.

E.

S.

DISCOVERY OF COMET 1892 V., Oct. 12, 1892.

BY E. E. BARNARD.

Exposure 4^h and 20^m; 6-inch Portrait Lens of Lick Observatory.

ON THE PHOTOGRAPHIC DISCOVERY OF COMET V 1892

E. E. BARNARD.

For Popular Astronomy.

On October 12, 1892, while continuing my work of photographing the Milky Way with the 6 in. Willard lens of this Observatory, I made an exposure to the north-west of Altair.

The plate was exposed from $6^h\ 40^m$ to $11^h\ 0^m$ Standard Pacific Time ($4^h\ 20^m$ duration).

Upon the development of this plate I found a short nebulous streak near the middle of it. I had previously made two phtographs of the same region—the last of which was on September 26. Nothing like this object had been seen upon either of the other plates.

Upon comparing with the previous negatives it was at once seen that the object must be new. By this time however, that part of the sky had set and no direct reference to the stars was possible.

If it had been a sharp clear cut line it would have suggested the presence of one of the asteroids. The streak however, was very nebulous, it must therefore be due to a comet whose motion had caused it to trail upon the plate. No known comet however was in that region; if a comet it must be a new one. It would only be possible to settle the question the next night.

As soon as it was dark on the 13th, I carefully swept with the 12-inch equatorial near the position of the object and soon found a very faint round nebulosity which after a few minutes' observation was seen to be a comet moving quite rapidly to the south-east. It was at once observed with the micrometer and proved to be the object that had left its trail on the plate the previous night.

One of the most surprising things about it was the extreme faintness of the comet. I had expected from the distinctness of the trail to see a fairly bright object. But it was scarcely brighter than the 13th magnitude. The light was therefore mainly photographic.

The comet was telegraphically announced that night and was subsequently observed at all the principal Observatories.

As if to more properly mark such a historical event, the orbit proved to be elliptical with a period of about six years.

There is a remarkable resemblance between the orbit of this comet and that of Wolf's of 1884—so much so indeed that it is probable they formed one body some time in the past.

This is the first comet discovered by photography, and so far as a complete verification is concerned by the computation of its orbit, it stands unique today, and is likely to so remain for some time to come.

The photograph is four times enlarged from the original. The scale is about 1 in. = 0°.5.

The position of the center of the trail is about

$$\alpha = 19^h\ 32^m,\ \delta = +\ 12^\circ\ 50'.$$

It will be seen that during the exposure the comet passed directly over several considerable stars.

The region of the Milky Way in which the comet was discovered is a remarkable one. Some small irregular vacancies exist here and there among the crowded stars, a couple of which will be seen on the enlargement south of the comet. The finest ones, however, are too distant to be included in the present picture.

Mt. Hamilton, Cal.
1895, May 29.

OBSERVATIONS FOR BEGINNERS.

W. W. PAYNE.

It is often asked by people interested in astronomy who have telescopes and who have had little experience in observing what they may do that will be useful to science. Such a query might be extended and made to include those who have only a field glass, an opera glass, or, desire to use the unaided eye. Such queries really involve two things. *What* to observe and *how* to observe. It is important to know what to observe that time may be wisely used, it is also quite as important to know *how* to observe that the best results may follow the attempts of the inexperienced. A moment's thought will show the beginner that either of these queries is very broad, and that both of them really concern every one interested in the elementary knowledge or elementary work in astronomy. To the more experienced the reason is plain enough why students or casual readers do not retain longer and more definitely the common facts of astronomy. The impression of the fact has not been fixed in the mind by some observational test outside of a book or other single source of information. We have five senses. We have two eyes to fix things in space. Our methods of attesting fact and adjusting truth are multiform. This should not be forgotten by early seekers after

knowledge. Indeed this is the principle of work used by all successful investigators in any particular line of research. The question most constantly recurring to such toilers is, how can I verify this or that impression or opinion in some other, independent way? In such ways only can new facts or truths grow in assurance and become, in time, certain knowledge.

As to what one may observe to be useful, will depend on experience and aptitude. Of course it would be useless for a person who is color blind to attempt a study of the colors of the stars. Neither will a person succeed well in any delicate observing who has defective eyes. While this is true it is also equally true that ordinary eyes when properly and persistently used will do wonders in any line of astronomical study. Work too difficult should not be undertaken at first. It is better to wait until experience has been gained by work that is comparatively easy, and that which will give definiteness of result so that powers of observation may be gradually tested, strengthened and consciously enlarged. For illustration, suppose we take so simple a matter as the names and places in the sky, of the first and second magnitude stars. For one who has not observed at all, or, but little at most, this may be the first lesson or piece of observational work. As simple and pleasureable to any one as this knowledge would be, we presume there is not one in every twenty of the average astronomers of the present time that knows all these stars at sight in his own latitude. Evidently there is something that the beginner can do that will soon give him knowledge comparable, in some respects, with that of the professional astronomer.

To undertake this work the self instructing beginner should have a planisphere which contains the names and places of these stars, as well as many other objects, with directions for finding them. Whitall's Planisphere, or Poole's, or even Harrington's will serve as a guide.

First make a table of the first magnitude stars with columns for the Arabic names and for those indicated by the Greek letters and the constellations in which they belong, reserving space for a third column to be used later for the observation of color and a fourth for general remarks. In a similar manner make another table for the second magnitude stars and in this way begin work in earnest, having before the mind at first only the names and places of these stars. Be sure that the Arabic names of the stars are pronounced as correctly as you know. For direction in this regard consult the best dictionary in reach and read Rev. R. H.

West's article in POPULAR ASTRONOMY, page 209 of volume II. Make a record of every observation in a blank book, of medium size for the sake of convenience, and follow Miss Mary E. Byrd's rules for observing:

1. Begin each night's record on a separate page.
2. Date each page of observations.
3. Record each night the place of observing and the time of beginning and ending.
4. Enter the record in connection with the observation, or immediately afterward.
5. Keep all records of observations in pencil.
6. Make all corrections of the original record, and enter copied observations in ink.

The success of this work, and all other as for that matter, will depend on the patience and perseverance of the person undertaking it. At first it will go slowly, very slowly, and the beginner will lose patience because he is able to do so little and what he does, seems to amount to so little. This is the common experience of all. Soon that impression will wear away and facility in doing will come, and interest and knowledge will improve.

Following this something more will be said next time on the same theme.

IS HELIUM TERRESTRIAL?

W. W. PAYNE.

It will be remembered that in 1860 photography at the time of the total solar eclipse of that year proved that the solar prominences, so called, belonged to the Sun and not to the Moon. In 1868 by the aid of the spectroscope, during a total eclipse these prominences were shown to be gaseous with hydrogen as the main constituent. Their spectrum also contained a conspicuous line in the yellow known as D_3, because it was near the two bright lines of sodium marked "*D*." This D_3 line does not belong to hydrogen, and until recently it has not been designated as belonging to any known terrestrial substance. It received the provisional name of "*helium*" because it was supposed to be peculiar to the Sun.

Interesting spectroscopic work of the present year calls attention particularly to this D_3 as related to terrestrial substances. It has been thought by some that a gas in a substance known as

Clèveite gives the line D_3. Very recent and careful measures by Professors William Huggins, Runge, Paschen, Hale and others reveal some interesting information in regard to the coincidence of these terrestrial and solar lines.

In the first place the helium line is undoubtedly double and hence a line from a like terrestrial substance should be double, and more than this, the components of each should correspond respectively the one with the other

Now, Professors Runge and Paschen have announced that the yellow line from Clèveite is double. But the measures of the respective components of the substances in Sun and Earth do not yet closely enough agree to make observers feel sure of the identity.

Again, Professor Ramsey in making some researches recently on the newly discovered Argon thought his most careful measures showed an identity between it and helium. But the more refined work by Professors Runge and Paschen still leaves this matter in doubt. In a recent publication at Berlin these observers "give the wave-lengths of each of the series of the lines due to helium as found from Cléveite and compare these with the wave-lengths of the corresponding hydrogen lines in the same spectrum." "The differences of the reciprocals of the wave-lengths, expressed in tenth-meters, is approximately constant, showing that the helium lines have a rhythmical relation to those of hydrogen." These are among the latest determinations of the wave-lengths of the helium lines known to us.

PROBABLE OBSERVATION OF BARNARD'S COMET OF 1884.

LEWIS SWIFT.

FOR POPULAR ASTRONOMY.

On every available occasion I have made a prolonged and desperate effort to detect this exceedingly faint comet which has eluded observation ever since its discovery in 1884. As was expected, it was not seen at its first return in 1890. On the morning of June 30, I observed, not far from the ephemeritic place of the comet, a faint, fairly large, nebulous object so cometary in appearance that I called in my son Edward, who was engaged in comet-seeking on the roof of the dark room just at hand, who instantly exclaimed, as he placed his eye to the telescope, "It is a beauty." Reading the rough circles from the floor of the Observatory, I made its place, right ascension $1^h\ 20^m\ 45^s$; declination

north 3°. As Sir William Herschel had several nebulæ in this region, notably G. C. 303, I unfortunately assumed my find to be one of his nebulæ for which I had looked and, though quite close to my object, had failed to find. Watching it for a half hour no motion was observed. It was curiously situated in relation to three stars of the ninth magnitude, forming a right angled triangle, and a close double-star = Σ No. 122. Upon mature reflection it seemed that this body might, after all, be a comet, and, if so, undoubtedly Barnard's. The morning of July 3rd found both my son and myself on hand and eager to know if the suspect still held its former place, but ere that region rose above the mountain a dense fog had enveloped us. The next morning, that of July 4th, the sky was beautifully clear, however, and the sixteen-inch telescope showed the triangle and the double star as we had previously seen them but the object had gone. Moonlight prevented for some time, further search. Assuming that the missing body was comet Barnard, and that it was, of course, moving easterly, my subsequent search has all been in that direction from the place of detection and has been increasing on every morning since, save when the Moon interfered.

Berberich, who has made a continuation of the ephemeris of the comet, assumes with too great positiveness, I think, that my find could not have been Barnard's comet. As this comet has been seen at but one apparition and that eleven years ago, quite naturally no very accurate ephemeris can be had. As a case in point, take my comet of 1880 discovered by Tempel in 1869 without suspicion that it was a periodic. It is similarly circumstanced to Barnard's, the period of each being about 5.5 years. Although this was accurately observed both in 1869 and in 1880 yet when found by Barnard in 1891 it was very much farther from the place assigned it in the ephemeris than was my suspect of June 30 (not the 29th as telegraphed). For instance, the place of my object was as follows:

R. A. $1^h\ 20^m\ 45^s$; Decl. $+\ 2°\ 55'\ 00''$

Ephemeris, same date,

R. A. $1^h\ 14^m\ 41^s$; Decl. $+\ 3°\ 25'\ 27''$

Difference R. A. $6^m\ 4^s$; Decl. $30'\ 27''$

Therefore, the suspect was about 6^m east and $30'$ south of the ephemeris place of the comet supposing it to have been in perihelion on June 3rd.

After the Moon withdraws, further search will, I fear, be but a waste of effort and energy as so long time has elapsed since perihelion passage.

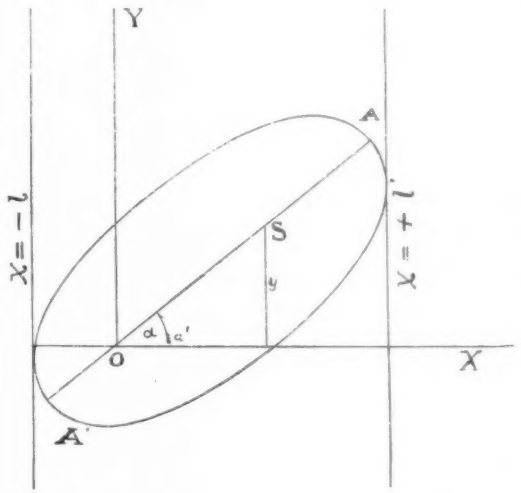
LOWE OBSERVATORY, Echo Mountain, California,
August 9, 1895.

THE DETERMINATION OF THE APPARENT POSITION OF THE ORBIT OF THE COMPANION OF A BINARY STAR.

J. HARRINGTON BOYD.

FOR POPULAR ASTRONOMY.

It is desired to find the equation to an orbit and show how to construct it from simple formulæ when we are given by observation the following data: The coördinates of one of the foci, the abscissa of the other and that the orbit touches two parallel lines.



The conception of this problem is due to Professor Burnham of the Yerkes Observatory.

The equation to a conical orbit in rectangular coördinates when one of the foci is at the origin and the center on the x-axis may be written in the form

$$x^2 + y^2 = e^2 (\sigma + x)^2 \qquad (1)$$

* Read before the Chicago Academy of Sciences.

where e is the eccentricity and σ the distance from the focus to the directrix.

If the coördinates be revolved in the xy-plane through an angle α, the equation of the conical orbit may then be found by putting respectively for x and y,

$$x \cos \alpha - y \sin \alpha \text{ and } x \sin \alpha + y \cos \alpha. \qquad (2)$$

Substituting those values for x and y in (1), the equation of the orbit becomes

$$x^2 + y^2 = e^2 (\sigma + x \cos \alpha - y \sin \alpha)^2. \qquad (3)$$

If the conic is to touch a line parallel to the y-axis, say $x = -l$, then the equation found by putting $x = -l$, in (3), namely

$$(1 - e^2 \sin^2 \alpha)\, y^2 + 2e^2 \sin \alpha\, (\sigma - l \cos \alpha)\, y + l^2 - e^2\sigma^2 - e^2 l^2 \cos^2 \alpha + 2e^2\sigma l \cos \alpha = 0, \qquad (4)$$

must have equal roots, which will be expressed by the equation

$$l^2 = e^2 (\sigma^2 + l^2 - 2\, \sigma l \cos \alpha). \qquad (5)$$

In like manner should the conic touch the line $x = l'$, (parallel to the line $x = -l$), then a second relation between e, σ and α must exist, namely,

$$l'^2 = e^2 (\sigma^2 + l'^2 + 2\sigma l' \cos \alpha) \qquad (6)$$

The two parallel lines $x = -l$ and $x = l'$ are taken as the parallel lines given by observation.

In order to determine the three unknown quantities in the conic represented by equation (3) we must have one more equation between the unknown quantities e, σ and α which may be found in the following manner:

The equation to the diameter of the orbit passing through the focus at the origin can be written in the form

$$\frac{x}{\cos \alpha} = \frac{y}{\sin \alpha} = \rho \qquad (7)$$

where ρ is the distance from the origin to the point (x, y).

By means of the equations in (7) we wish to find an expression for the major axis of the conical orbit. This may be accomplished as follows:

From equations (7) and (3)

$$\pm \rho = e (\sigma + \rho \cos^2 \alpha - \rho \sin^2 \alpha)$$

$$\rho = \frac{e\sigma}{1 - e \cos 2\alpha} = \mathrm{OA}, \text{ or } -\rho = \frac{e\sigma}{1 + e \cos 2\alpha} = \mathrm{OA}' \qquad (8)$$

$$\mathrm{AA}' = \frac{2e\sigma}{1 - e^2 \cos^2 2\alpha}, \quad \mathrm{OS} = e\,\mathrm{AA}' = \frac{2e^2\sigma}{1 - e^2 \cos^2 2\alpha}$$

Represent the coördinates of the second focus S by (a', y) where a' is given by observation and y unknown, then

$$y = a' \tan \alpha = \text{OS} \sin \alpha,$$

hence

$$\frac{a'}{\cos \alpha} = \frac{2e^2\sigma}{1 - e^2 \cos^2 2\alpha}. \tag{9}$$

Equations (5), (6) and (9) solved for e, σ and $\cos \alpha$ determine the unknown parameters of equation (3).

Eliminating e^2 from (5) and (6), (5) and (9)

$$\cos \alpha = \lambda\sigma, \text{ where } \lambda = \frac{l' - l}{2ll'}, \tag{10}$$

$$2l(l + a') \cos \alpha\sigma - a'\sigma^2 - a'l^2 + a'l^2 \cos^2 2\alpha = 0.$$

Eliminating $\cos \alpha$ from equations in (10)

$$a' - 2l\lambda (l + a') - 4l^2\lambda^2 a' + 4a'l^2\lambda^4\sigma^2 = 0. \tag{11}$$

From (11) and (10) we find the following expression for σ and $\cos \alpha$

$$\sigma = \frac{\pm 1}{2l\lambda^2}\sqrt{1 - 2l\lambda\left(1 + \frac{l}{a'}\right) - 4l^2\lambda^2}, \tag{12}$$

$$\cos \alpha = \frac{\pm 1}{2l\lambda}\sqrt{1 - 2l\lambda\left(1 + \frac{l}{a'}\right) - 4l^2\lambda^2}.$$

The quantities l, l' and a' are known by observation and λ by an equation in (10). The last formula in (12) shows the positon of the ellipse by indicating the direction of the major axis. The value for σ and $\cos \alpha$ substituted in (5), (6) or (9) will give us a value for e, then the value of e, σ and $\cos \alpha$ substituted in the expression for AA' in (8) will give in the major axis from which the orbit may be constructed in the well known manner.

SOME INTERESTING RESULTS OF HELMHOLTZ'S THEORY OF SOLAR CONTRACTION.

ERIC DOOLITTLE.

For Popular Astronomy.

In a course of lectures which Dr. T. J. J. See is giving at this university on the theory of the heat of the Sun, he has developed the formulæ used by Helmholtz, and has suggested that some applications of them would be of general interest.

One of these is very simple in its derivation, and leads to results

of the utmost importance. We shall see that it not only gives us the total amount of heat radiated by the Sun during the past ages, but that it enables us also to form an idea of the way in which the heat was given out as the original solar nebula contracted, stage by stage, under its own gravitation.

It points out to us the surprising result, that while the amount of heat radiated in the contraction of the Sun from indefinite expansion until it came within the orbit of Mercury is very great, still it is only about *one eighty-third* of what has been radiated since the nebula reached this stage.

Let us suppose that the Sun was originally expanded into a gaseous nebula, and that it began gradually to contract in accordance with Laplace's hypothesis. We shall derive a formula for the amount of heat given off by a contraction from a radius R_0 to a radius R; and we shall at first assume that the nebulous mass is spherical and homogeneous.

The Potential of a mass, M, upon a unit particle at a distance r, is, according to Laplace's definition $\frac{M}{r}$. If the attracting mass is spherical, this is the same as the work done in moving the particle from a distance r to infinity against the attracting force. For, the sphere will attract precisely as if its mass were collected at its center, and it will therefore attract a unit particle at a distance r with a force $\frac{M}{r^2}$. If the unit particle be moved against the attracting force a distance Δr, the work done is $\frac{M}{r^2}\Delta r$. And hence if the particle be moved to an indefinite distance, the whole work is

$$\int_R^\infty \frac{M}{r^2}\, dr, \text{ or } \frac{M}{R}$$

Let R be the radius of the Sun at any time and σ its density. Then the work required to bring a unit element from infinity to the Sun's surface will be,

$$\frac{4/3\,\pi\,\sigma\,R^3}{R} \qquad (1)$$

The mass of the spherical shell in which this element lies is,

$$4\pi\sigma R^2 \Delta R \qquad (2)$$

and hence the total work required to bring all of the elements of the surface from an infinite distance to their present position is the product of (1) and (2), or

$$\Delta W = \frac{4/3\pi\sigma R^3}{R} \times 4\pi\sigma k^2 \Delta R \qquad (3)$$

This is the potential of a sphere of radius R upon a concentric surface of thickness ΔR.

Now if we remember that the attraction of a spherical shell upon a particle within is zero, we see that the total work done, as the Sun contracts from a radius ∞ to a radius R_0, is

$$\int_{R_0}^{\infty} \frac{dW}{dR}\, dR;$$

and in contracting from ∞ to R_1,

$$\int_{R_1}^{\infty} \frac{dW}{dR}\, dR.$$

Hence in contracting from R_0 to R_1 the work is

$$\int_{R_1}^{R_0} \frac{dW}{dR}\, dR,$$

and this from (3) is found to be

$$W = \frac{3}{5}\frac{M^2}{R_1}\left(1 - \frac{R_1}{R_0}\right) \qquad (4)$$

It now merely remains to express (4) in heat units.

To raise the temperature of a mass M, of specific heat y, t degrees centigrade, it requires an amount of heat Myt. To convert this into work we multiply it by the mechanical equivalent of heat Ag, where A is the distance 424 meters. Thus $Myt \cdot Ag$ is the work required to raise the temperature of this mass through t degrees.

We may equate this with the amount of work we have found in (4), and solve for t. And we may multiply our result by $\frac{r^2}{m}g$, which is equivalent to unity, if r and m are the radius and mass of the Earth respectively.

Thus we finally get,

$$t = \frac{5}{3}\frac{M}{m} \cdot \frac{r^2}{AyR_1}\left(1 - \frac{R_1}{R_0}\right) \qquad (5)$$

M is to be taken $330{,}000m$, and r is 6,378,190 meters.

If we let y equal unity and R_1 be 697,235,000 meters, the radius of the Sun, we shall have an expression for the number of degrees centigrade through which a quantity of water equal in mass to the Sun would be raised by the heat which the Sun gave up in contracting from a radius R_0 to its present size.

In this way the following table has been prepared. The second

column gives the successive values of R_0, and the third the values of t in thousand degrees centigrade. The last column gives the quotient obtained by dividing the amount of heat emitted in contracting from infinity to R_0 by the total amount which has been given off.

Planets.	Distance in millions of Kilometers.	t in thousand Degrees.	
——	∞	27249.0	
Neptune	4492.6	27244.8	.00016
Uranus	2867.7	27242.4	.00025
Saturn	1425.9	27235.7	.00049
Jupiter	777.8	27224.6	.00090
Ceres	413.7	27203.1	.00168
Mars	227.7	27165.6	.00306
Earth	149.5	27121.9	.00407
Venus	108.2	27073.3	.00644
Mercury	57.9	26921.1	.01203
——	40.0	26774.1	.01743
——	25.0	26489.1	.02789
——	15.0	25982.5	.04648
——	8.0	24874.4	.08517
——	3.0	20916.4	.23239
——	2.0	17750.4	.34858
——	1.5	14584.0	.46478
The Sun's Surface.	.6972	0	1

This shows us that if the solar nebula was of indefinite extent, the whole amount of heat is represented by the enormous number 27,249,000° Centigrade, and if the Sun in the beginning extended only to the planet Neptune, the whole amount would be 27,244,800°. Thus the heat radiated in contracting from infinite expansion to the planet Neptune is only .00016 times as great as the whole amount: that is but $\frac{1}{6244}$th part of it.

It is a surprising result that there is comparatively little radiation until the nebula has contracted to a radius of only forty million kilometers, one one-hundredth part of the distance to Neptune.

Regarding R_0 as constant, and differentiating (5), we have

$$\frac{dt}{dR} = -\frac{3}{5}\frac{M}{m}\cdot\frac{r^2}{AyR^2}$$

If we let $\Delta R = \frac{1}{10000} R$, we find $\Delta t = 2725°$ C, or in shrinking $\frac{1}{10000}$th part of the present radius the Sun gives out heat enough to raise the same mass of water 2725°. Puillet found by experiments on solar radiation that the observed *annual* value of Δt is 1°.25 C. Thus an annual contraction of $\frac{1.25}{2725} \times \frac{R}{10000}$, or of only 32.13 meters is sufficient to maintain the present radiation.

We have considered the Sun as a homogeneous body, but it is almost certainly denser in the central part.

It seems clear that this increase of density would result in an increase of potential, and hence in an increase in radiation. The numbers in the third column of our table would thus all be increased, but whether the comparative radiation in the beginning would be so exceedingly small is more uncertain.

Since at first the nebula was probably nearly homogeneous, perhaps the first few numbers are not far from the truth. But as soon as the increased density toward the centre begins to be considerable, we should add to the corresponding values of t the energy given up in transferring various particles from their position in a homogeneous sphere to their more central position in a heterogeneous sphere of the same radius.

This might perhaps make the values of t descend more rapidly.

It is an easy and very interesting matter to apply formula (5) to investigate the future solar radiation, and it may also be applied to the planets. In the latter case the heat given up will be relatively insignificant. Even in the case of Jupiter the whole heat radiated cannot exceed $\frac{1}{100000}$th part of that which the Sun has given up, and the heat of all the planets with their satellites is comparatively insensible.

UNIVERSITY OF CHICAGO, July 15, 1895.

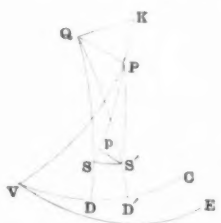
THE SOLAR EPHEMERIS.*

J. MORRISON, M. A., M. B., PH. D.

FOR POPULAR ASTRONOMY.

The retrograde motions of the equinoxes must of course affect the right ascension and declination of a celestial body. By the aid of the diagrams the corrections for both precession and nutation may be easily found as follows:

PRECESSION IN R. A. AND DECL.



Let P be the pole of the equator VE, Q of the ecliptic VC, S and S' two apparent consecutive positions of a body after an interval of t years; then $SPS' = a$, is the precession in R. A., and $Sp = b$, the precession in Decl., $S'p$ being perpendicular to PS. The colatitude QS, QS' remaining unchanged, the precession in longitude is $SQS' = 50''.2t$. Produce SP to K so that $SK = 90°$. PK will then be the declination δ, join QK; then we shall have

* Continued from page 414.

$a \sin PS' = S'p = SS' \sin S'Sp$, but $SS' = 50''.2\ t \sin QS$,
$= 50''.2\ t \sin QS \cos PSQ$,
and since $\cos KQ = \cos KS \cos QS + \sin KS \sin QS \cos KSQ$,
$= \sin QS \cos KSQ$,
therefore $a \sin PS = 50''.2\ t \cos KQ$,
$= 50''.2\ t\ (\cos KP \cos PQ +$
$\sin KP \sin PQ \cos KPQ)$.
$= 50''.2\ t\ (\cos \delta \cos \omega + \sin \delta \sin \omega \sin \alpha)$.

because $PS' = PS$ very nearly and therefore we have

$$a \cos \delta = 50''.2\ t\ (\cos \delta \cos \omega + \sin \delta \sin \omega \sin \alpha)$$

or

$$a = 50''.2\ t\ (\cos \omega + \sin \omega \tan \delta \sin \alpha). \qquad (4)$$

Again Sp or $b = S'S \cos S'Sp = 50''.2\ t \sin QS \sin PSQ$, approximately, the angles PSS' and PSQ being very nearly complementary,

But, $\sin QS \sin PSQ = \sin PQ \sin QPS$

therefore $b = 50''.2\ t \sin PQ \sin QPS$
$= 50''.2\ t \sin \omega \sin (90^\circ + \alpha)$
$= 50''.2\ t \sin \omega \cos \alpha \qquad (5)$

If we make $t = 1$ year we shall have

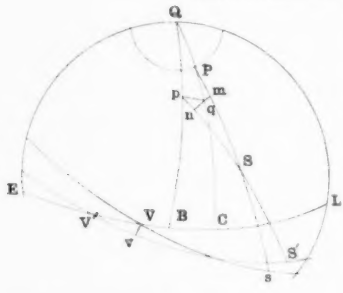
Annual precession in R. A., $\Delta\alpha = m + n \sin \alpha \tan \delta$

Annual precession in Decl., $\Delta\delta = n \cos \alpha$

where $m = 50''.2 \cos \omega$, and $n = 50''.2 \sin \omega$
$= 46''.0256$, $= 20''.0426$,

approximately. (See expression for a and a', *Am. Ephem.* page 280). The quantities m and n involve neither the R. A. nor the Decl. The term $50''.2\ t \cos \omega$ is expressive of that part of the precession in R. A. which is common to all stars. If the star's R. A. exceeds 12 hours, $\sin \alpha$ is negative and consequently the second term of (4) becomes negative and if it exceeds the first term, the precession in R. A. will be negative which happens with β Ursæ Minoris and others.

NUTATION IN R. A. AND DECL.



Let Q be the pole of the ecliptic, ECL, P the pole of the mean equator Vs, and p the place of the pole of the true equator $V'S'$. Now QP and Qp can differ only by the half of $18''.5$ or $9''.25$ at most; $QP = \omega$ then $Qp = \omega + \Delta\omega$, and let $pQP = \Delta l$, where $\Delta\omega$ and Δl denote the nutation in the obliquity and longitude respectively. Let S be the position of a celestial body, then Vs is its mean R. A. and Ss

its mean Decl.; $V'S'$ its true R. A. and pS' its true Decl.; both *R. A. and Decl. as affected by nutation.*

Draw pq perpendicular to QP, nqm perpendicular to PS or pS and Vv perpendicular to $V'S'$: then we shall have

Nut. in R. A. $= V'S' - Vs = V'v + DS'$* approximately.

But $V'v = VV' \cos \omega = \Delta l \cos \omega$, and from the right-angled triangles DSS' and mnS we have

$$\cos \delta = \tan mn \cot S$$

and $$\sin \delta = \tan DS' \cot S$$

hence $$\tan \delta = \frac{\tan DS'}{\tan mn} = \frac{DS'}{mn}$$

since we may here use DS' and mn for their tangents

therefore $$DS' = mn \tan \delta$$

and Nut. in R. A.

$$= \Delta l \cos \omega + mn \tan \delta$$
$$= \Delta l \cos \omega + (mq + nq) \tan \delta$$
$$= \Delta l \cos \omega + (- Pq \cos \alpha + pq \sin \alpha) \tan \delta$$
$$= \Delta l \cos \omega - \Delta \omega \cos \alpha \tan \delta + \Delta l \sin \alpha \sin \omega \tan \delta$$
$$= \Delta l (\cos \omega + \sin \alpha \sin \omega \tan \delta) - \Delta \omega \cos \alpha \tan \delta \quad (6)$$

Again in the triangle Qpq, we have (using pq and Δl for their sines), $pq = \Delta l \sin \omega$ and $Pq = \Delta \omega$ very nearly.

Then Nut. in Decl. $= PS - pS = Pm - pn$, approximately,

$$= Pq \cos (\alpha - 90^\circ) - pq \sin (\alpha - 90^\circ)$$
$$= \Delta \omega \sin \alpha + \Delta l \cos \alpha \sin \omega \quad (7)$$

Investigations in Physical Astronomy have shown that

$\Delta l = - 17''.2524 \sin \varsigma + 0''.2063 \sin 2\varsigma - 1''.2691 \sin 2\odot$

and

$\Delta \omega = \quad 9''.2237 \cos \varsigma - 0''.0895 \cos 2\varsigma + 0''.5507 \cos 2\odot$

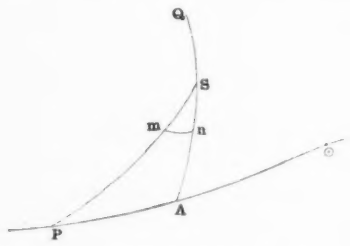
where ς is the mean longitude of the Moon's ascending node and $\odot$ the true longitude of the Sun.

Aberration.

The next correction to be considered is aberration which is one of the most pleasing and refined subjects in astronomy. It furnishes us with a direct proof of the orbital motion of the earth and is due to the fact that light is not propagated instantaneously, but its velocity bears a sensible ratio to that of the spectator, resulting from the motion of the Earth in her orbit. In consequence of aberration the celestial bodies are not seen in the positions they really occupy, but are made visible by light which left them some

* The letter D was omitted in the copy for the cut and it was not noticed until after the cut was made. D should be at the intersection of lines Ss and $V'S'$.—*Ed.*

time previously during which both we and they have changed our position in space. Aberration takes place in the plane passing through the body, the Earth and the tangent to the Earth's orbit, and is always in the direction to which the Earth is moving, that is, to the point of the ecliptic 90° behind the Sun's place, and consequently the body is elevated or depressed with regard to the direction of the Earth's motion, according as the Earth is receding from or approaching the body. If we denote the angle which a line joining the Earth and body makes with the direction of the Earth's motion by $\oplus$, which is technically called the angle of the "Earth's way," then it is very easy to show that the aberration $= \frac{\text{velocity of Earth}}{\text{velocity of light}} \cdot \sin \oplus = h \sin \oplus$, where h is a constant and is found as follows: If R denote the radius of Earth's orbit and L the velocity of light per second, then $\frac{R}{L}$ = number of seconds required for light to pass from the Sun to the Earth = 498 seconds, during which time the Sun (or rather the Earth) will move through $\frac{498}{365.256d} \times 2\pi R$, or in seconds of arc, $20''.445 = h$. This mean value of h is subject to slight variations, not much exceeding $0''.33$, in consequence of the variable motion of the Earth in its orbit. As the plane in which aberration takes place is always changing its position in space, the effect will be to make the bodies when referred to the celestial sphere, describe curves about their true place Thus, let $PA\odot$ be an arc of the ecliptic, P the point to which the Earth is moving, $\odot$ the Sun, 90° in advance, Q the pole of the ecliptic and S a star, then SP measures the angle of the "Earth's way," and SA the star's latitude. In SP take $Sm = h \sin PS$, m will then be the star's *apparent* place or its place as affected by aberration. Draw mn perpendicular to AQ and let $mn = x$ and $Sn = y$, then we have:



$$x = mn = Sm \sin mSn = h \sin PS \sin mSn = h \sin AP$$
$$y = Sn = Sm \cos mSn = h \sin PS \cos mSn = h \sin AS \cos AP.$$

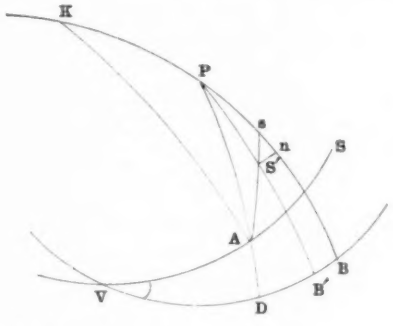
Dividing each of these equations by h, squaring and adding we have

$$\left(\frac{x}{h}\right)^2 + \left(\frac{y}{h \sin AS}\right)^2 = 1$$

which is the equation of an ellipse whose semi-axes are h and h sin AS or 20″.445 and 20″.445 sin lat., the major axis being parallel to the ecliptic.

If the lat. = 90°, or the body is at the pole of the ecliptic, then the ellipse becomes a circle and if lat. = 0, then we have $x = h \sin AP = h \cos(\lambda - \odot)$ where λ and $\odot$ are the longitudes, of the star and Sun respectively. This is the equation of a straight line and therefore the body will appear to vibrate about its mean place.

ABERRATION IN R. A. AND DECL.



In the diagram let VS be the ecliptic, VB the equator, P its pole, s the position of a star and A a point 90° behind S, the Sun, and S' its apparent position.

Draw $S'n$ perpendicular to PB and take $s\,K = 90°$, then BB' or BPB' is the aberration in R. A. and sn in Decl., VB the star's R. A. $= \alpha$ and sB its Decl $= \delta$.

We have

$$\begin{aligned} S'n &= S's \sin S'sn \\ &= h \sin As \sin S'sn \\ &= h \sin AP \sin APs \\ &= h \cos AD \sin DB \\ &= h \cos AD \sin (\alpha - VD) \\ &= h \cos AD \sin \alpha \cos VD - h \cos AD \cos \alpha \sin VD \\ &= h \sin \alpha \cos VA - h \cos \alpha \cos \omega^* \sin VA \end{aligned}$$

but $VA = \odot - 90°$, $\odot$ being the Sun's longitude, therefore

$$S'n = h(\sin \alpha \sin \odot + \cos \alpha \cos \omega \cos \odot)$$

and the aberration in R. A.

$$\begin{aligned} &= -S'n \sec \delta \\ &= -h \sec \delta \,(\sin \alpha \sin \odot + \cos \alpha \cos \omega \cos \odot) \qquad (8) \\ &= \text{apparent R. A.} - \text{true R. A.} \end{aligned}$$

The aberration in declination is $-sn$,

* Angle $SVB = \omega$

but $-sn = -sS' \cos S'sn$

$= h \sin As \cos AsP$

$= h \cos AK$

$= h \cos AP \cos PK - \sin AP \sin PK \cos APK$

$= h (\sin AD \cos sB - \cos AD \sin sB \cos (\alpha - VD)$

$= h (\sin (\odot - 90^{\circ}) \sin \omega \cos \delta - \sin \delta \cos AD \cos \alpha \cos VD$
$- \sin \delta \cos AD \sin \alpha \sin VD)$

$= h (-\cos \odot \sin \omega \cos \delta - \sin \delta \cos \alpha \cos VA$
$- \sin \delta \sin \alpha \cos \omega \sin VA)$

therefore the aberration in declination

$= -h (\cos \odot \sin \omega \cos \delta + \sin \delta \cos \alpha \sin \odot$
$- \sin \delta \sin \alpha \cos \omega \cos \odot)$ (9)

= apparent Decl. — true Decl.

In the case of the Sun, Moon and planets the aberration is easily found thus: Let Δ denote the distance of the body from the Earth expressed in terms of the Earth's mean distance from the Sun regarded as unity, and m'' the *geocentric* motion of the body in *one* second of time, we shall evidently have

$$\text{the aberration} = 498 \Delta m \text{ (in seconds of arc)} \qquad (10)$$

This quantity can of course be resolved in any direction and will preserve the same ratio to the body's geocentric motion when resolved in the same directions, hence it follows that if T denote the true and A the apparent longitude, latitude, R. A. or Decl. of a celestial body and m the geocentric motion of the same quantities in one second, we shall have

$$A - T = 498'' \Delta m \qquad (11)$$

For the Sun we always have

$$\text{Apparent long.} = \text{true long.} - 20''.445 \, R$$

where R denotes the radius vector.

In the case of the Moon whose distance from the Earth is about $\frac{1}{400}$ of that of the Sun the aberration will always be about

$$0''.5 \text{ or } \frac{20''.445}{400}$$

The student should make himself perfectly familiar with these formulæ which find an extensive application in the computation of the apparent places of the fixed stars, Sun and planets.

Before dismissing the consideration of these astronomical corrections we may remark that, in the inequalities of precession, aberration and nutation, observation preceded theory. They

were first detected as phenomena and their physical cause discovered afterwards, except in the case of that portion of the nutation which depends on the Sun. From its extreme minuteness it could never be perceived as a phenomenon but was first conjectured to exist from analogy. The inequality of the Moon's force in generating precession being found to produce a lunar nutation, that of the Sun was also presumed to cause a solar nutation resembling the lunar. Its law has been investigated and its quantity computed and added to the lunar portion thus making what is called the luni-solar nutation.

After this long digression we will now resume the consideration of the solar ephemeris and will commence with the column headed "Sidereal time of semi-diameter passing the meridian."

Let m = the increase of the Sun's R. A. in one mean solar second, then since any meridian moves 15″ in one sidereal second, $15''\mu - m''$ = the gain of the meridian on the Sun, in the same interval, where $\mu = 1.00273791$ the ratio of a mean solar to a sidereal day.

If d denote the Sun's semi-diameter, then $\frac{d}{15\mu - m}$ = number of mean solar seconds in which the Sun's semi-diameter crosses the meridian, when the Sun is on the equator, and for any declination δ, it will be $\frac{d}{(15\mu - m)\cos\delta}$ in mean time or, if t_s denote the sidereal interval, we shall have

$$t_s = \frac{d\mu}{(15\mu - m)\cos\delta}$$

$$= \frac{d}{(15 - .9972696m)\cos\delta} \qquad (12)$$

The value of m can be found from the tabulated R. A. or the hourly variation of the same in the adjoining column.

The sidereal time occupied by the Sun's semi-diameter in crossing the meridian can also be found without using the value of m as follows:

Let R denote the Earth's radius vector and T the length of a tropical year in days, then the increase of the Sun's longitude in one sidereal day $= \frac{360^\circ}{R^2(T+1)}$, by the principles of elliptic motion, and when this is reduced to the equator the increase in R. A. $= \frac{360^\circ}{R^2(T+1)} \cdot \frac{\cos\omega}{\cos^2\delta}$, for in the right spherical triangle formed by the longitude (l), the R. A. (α), and Decl. (δ), we have

$$\tan \alpha = \cos \omega, \tan l$$

and
$$\frac{\frac{d\alpha}{dt}}{\cos^2 \alpha} = \frac{\cos \omega \frac{dl}{dt}}{\cos^2 l} = \frac{\cos \omega \frac{dl}{dt}}{\cos^2 \alpha \cos^2 \delta}$$

tkerefore
$$\frac{d\alpha}{dt} = \frac{dl}{dt} \cdot \cos \omega \sec^2 \delta$$

that is, the Sun's increment in longitude is reduced to that in R. A. by multiplying the former by $\cos \omega \sec^2 \delta$.

[If $d\alpha = dl$, *i. e.* when $(l - \alpha)$ is a maximum, the above equation furnishes a solution of Problem 2.]

Hence it follows that in one sidereal second the Sun's centre recedes from the equinoctial point by $\frac{15''}{R^2(T+1)} \frac{\cos \omega}{\cos^2 \delta}$, and in the same time the meridian recedes from the same by 15″, consequently the gain of the meridian on that passing through the Sun's centre is

$$15'' \left(1 - \frac{\cos \omega}{R^2 (T+1) \cos^2 \delta}\right)$$

The Sun's semi-diameter at mean distance is $16'\ 2'' = 962''$ and at distance R it is $\frac{962''}{R} = d$ and the angle which this subtends at the pole of the equator is $\frac{d}{\cos \delta}$, hence we have

$$15''\left(1 - \frac{\cos \omega}{R^2 (T+1) \cos^2 \delta}\right) t_s = \frac{d}{\cos \delta}$$

whence
$$t_s = \frac{64''.13\ R^2 (T+1) \cos \delta}{R^2 (T+1) \cos^2 \delta - \cos \omega} \qquad (13)$$

which may be easily adapted to logarithmic computation, the factor $64''.13\ (T+1)$ being constant and ω the apparent obliquity of the ecliptic.

[TO BE CONTINUED.]

PROBLEMS.

8. Show that when the equation of the centre is a maximum,

$$\cos E = \frac{1 - (1 - e^2)^{\frac{1}{2}}}{e}$$

where E is the eccentric anomaly and e the eccentricity.

9. Find the R.A. of a star for which the aberration in R.A. vanishes at the summer solstice.

10. Suppose the difference between the declination of a star at the pole of the ecliptic in March 21 and Sept. 21, is 41″, find the velocity of light, the Sun's distance being 92,500,000 miles and the year of 365.256 days.

11. If the aberration of a star in long. be equal to that in lat. prove that

$$\sin 2\beta = 2 \cot (\odot - l)$$

where l and β are the long. and lat. of the star and $\odot$ the long. of the Sun.

12. Is there a time when all stars which lie in a certain great circle, *have no* aberration? And if not, why not?

13. If $\triangle \omega$ denote the change of the obliquity due to nutation show that the changes in the R. A. and Decl. are

$$\triangle \alpha = - \tan \delta \triangle \omega$$
$$\triangle \delta = \sin \alpha \triangle \omega$$

14. The zenith distances of a star when it crosses the meridian and prime vertical are z and z', and if δ be the Decl. and φ the lat. of the place show that

$$\cot \delta = \operatorname{cosec} z \sec z' - \cot z$$

and

$$\cot \varphi = \cot z - \operatorname{cosec} z \cos z'$$

PLANET NOTES FOR SEPTEMBER AND OCTOBER.

H. C. WILSON.

Mercury, *Venus* and *Mars* begin the month of September nearly in line and all quite close to the Sun, as seen from the Earth, Mercury and Mars on the farther side and Venus this side of the Sun. Mercury and Mars will be in conjunction in right ascension on the morning of Sept. 1 and only 1′ apart in declination. Mercury and Venus will be in conjunction, but about 10° apart in declination on the evening of Sept. 5. Venus and Mars will be in conjunction, 10° apart in declination on the evening of Sept. 9. By referring to the diagram one will easily see the difference in their movements during the two months. Mars, moving forward more slowly than the Earth, falls behind the Sun, reaching conjunction on the morning of Oct. 11. Mercury moving more rapidly comes out from behind the Sun; is at greatest eastern elongation Oct. 1; passes quickly between the Earth and Sun and is at inferior conjunction Oct. 25. Venus, moving between the Sun and Earth catches up with the latter,—is at inferior conjunction,—at midnight Sept. 18, and thereafter becomes morning planet.

Jupiter is coming into position for observation in the morning. He is in the constellation Cancer, southeast from Castor and Pollux. He will be at quadrature, 90° west from the Sun on the last day of October. From the 1st to the 20th of October Jupiter will be just south of the Præsepe cluster of stars, but not close enough to occult any of them.

Saturn and Uranus are approaching conjunction with the Sun and so are not in favorable position for observation.

THE PLANETS AND THE ZODIAC FOR SEPTEMBER AND OCTOBER.

Neptune is in Taurus about 1° southwest of the star *n*. This planet may be observed in the morning, but only with telescopes of considerable power.

Planet Tables for September and October.

[The times given are local time for Northfield. To obtain Standard Times for places in approximately the same latitude, add the difference between Standard and Local Time if west of the Standard Meridian or subtract if east.]

MERCURY.

Date.	h m R. A.	° ′ Decl.	h m Rises.	h m Transits.	h m Sets.
Sept. 5.....	11 56.9	+ 0 44	6 52 A. M.	12 58.4 P. M.	7 5 P. M.
15.....	12 50.9	− 6 27	7 35 "	1 12.8 "	6 51 "
25.....	13 38.4	− 12 35	8 7 "	1 21.0 "	6 35 "
Oct. 5.....	14 16.1	− 17 0	8 26 "	1 19.4 "	6 13 "
15.....	14 30.0	− 17 58	7 59 "	12 48.9 "	5 38 "
25.....	13 55.4	− 12 27	5 23 "	11 36.1 A. M.	4 49 "

VENUS.

Sept.	5	11	57.8	−	8	19	7	29	A. M.	12	59.3 P. M.	6	30 P. M.
	15	11	39.5	−	7	14	6	27	"	12	1.6 "	5	36 "
	25	11	18.8	−	4	21	5	16	"	11	1.9 A. M.	4	48 "
Oct.	5	11	7.6	−	1	13	4	13	"	10	11.3 "	4	10 "
	15	11	11.1	+	0	46	3	29	"	9	35.3 "	3	42 "
	25	11	27.4	+	1	12	3	4	"	9	12.4 "	3	20 "

MARS.

Sept.	5	11	41.3	+	2	57	6	28	A. M.	12	42.8 P. M.	6	58 P. M.
	15	12	4.9	+	0	19	6	22	"	12	27.0 "	6	32 "
	25	12	28.7	−	2	20	6	17	"	12	11.5 "	7	6 "
Oct.	5	12	52.8	−	4	58	6	12	"	11	56.1 A. M.	5	40 "
	15	13	17.3	−	7	35	6	8	"	11	41.2 "	5	15 "
	25	13	42.3	−	10	7	6	4	"	11	26.9 "	4	50 "

JUPITER.

Sept.	5	8	9.6	+	20	24	1	42	A. M.	9	11.8 A. M.	4	41 P. M.
	15	8	17.3	+	20	1	1	12	"	8	40.1 "	4	8 "
	25	8	24.4	+	19	39	12	42	"	8	7.8 "	3	34 "
Oct.	5	8	30 6	+	19	18	12	11	"	7	34.8 "	2	59 "
	15	8	36.0	+	19	0	11	38	P. M.	7	0.9 "	2	24 "
	25	8	40.5	+	18	45	11	4	"	6	26.0 "	1	48 "

SATURN.

Sept.	5	14	8.6	−	10	36	9	49	A. M.	3	9.8 P. M.	8	31 P. M.
	15	14	12.2	−	10	57	9	14	"	2	34.1 "	7	54 "
	25	14	16.1	−	11	18	8	41	"	1	58.7 "	7	17 "
Oct.	5	14	20 4	−	11	42	8	7	"	1	23 6 "	6	40 "
	15	14	24.9	−	12	5	7	34	"	12	48.7 "	6	4 "
	25	14	29.4	−	12	28	7	0	"	12	13.9 "	5	27 "

URANUS.

Sept.	5	14	57.0	−	16	31	11	2	A. M.	3	58.1 P. M.	8	54 P. M.
	15	14	58.5	−	16	38	10	25	"	3	20.3 "	8	16 "
	25	15	0.3	−	16	46	9	48	"	2	42.8 "	7	38 "
Oct.	5	15	2.4	−	16	55	9	11	"	2	5.5 "	7	0 "
	15	15	4.6	−	17	4	8	35	"	1	28.4 "	6	22 "
	25	15	6.9	−	17	14	7	59	"	12	51.4 "	5	44 "

NEPTUNE.

Sept.	5	5	8.4	+	21	28	10	32	P. M.	6	7.0 A. M.	1	42 P. M.
	15	5	8.6	+	21	28	9	53	"	5	27.9 "	1	2 "
	25	5	8.6	+	21	28	9	14	"	4	48.6 "	12	23 "
Oct.	5	5	8.4	+	21	27	8	34	"	4	9.0 "	11	44 A. M.
	15	5	7.9	+	21	26	7	55	"	3	29.2 "	11	4 "
	25	5	7.2	+	21	25	7	15	"	2	49.2 "	10	24 "

SUN.

Sept.	5	10	57.0	+	6	43	5	27	A. M.	11	58.6 A. M.	6	30 P. M.
	15	11	33.0	+	2	56	5	39	"	11	55.1 "	6	11 "
	25	12	8.9	−	0	58	5	51	"	11	51.6 "	5	52 "
Oct.	5	12	45.1	−	4	50	6	3	"	11	48.4 "	5	34 "
	15	13	21.9	−	8	38	6	16	"	11	45.8 "	5	16 "
	25	13	59.7	−	12	13	6	29	"	11	44.2 "	5	0 "

Variables of the Algol Type.

No.	Name.	Place 1900. R. A. h m s	Decl. ° ′	Mag. Max. m	Min. m	Period. d h m	Duration of change. h
320	U Cephei	0 53 23	+81 20.2	7.2	9.2	2 11 50	10
1090	β Persei (Algol)	3 1 40	+40 34.2	2.3	3.5	2 20 49	9
1411	λ Tauri	3 55 8	+12 12.5	3.4	4.2	3 22 52	10
2610	R Canis Maj	7 14 56	−16 12.4	5.9	6.7	1 3 16	5
3109	S Cancri	8 38 14	+19 23.6	8.2	9.8	9 11 38	21½
3407	S Antliæ	9 27 56	−28 11.2	6.7	7.3	0 7 47	3½
5374	δ Libræ	14 55 38	−8 7.3	5.0	6.2	2 7 51	12
5484	U Coronæ	15 14 7	+32 0.8	7.5	8.9	3 10 51	10
6189	U Ophiuchi	17 11 27	+1 19.3	6.0	6.7	0 20 8	5
6442	Z Herculis	17 53 36	+15 8.8	7.1	8.0?	3 23 50*	
7488	Y Cygni	20 48 4	+34 17.0	7.1	7.9	1 11 57	8

* Secondary minima about 45h later.

Minima of the Variable Stars of the Algol Type.

[Given to the nearest hour in Central Standard Time.]

U CEPHEI.

	d	h
Sept.	4	16
	9	16
	14	16
	19	15
	24	15
	29	15
Oct.	4	14
	9	14
	14	14
	19	13
	24	13
	29	13

ALGOL.

Sept.	1	11
	4	8
	7	5
	15	19
	18	16
	21	13
	24	9
	27	6
Oct.	8	18
	11	14
	14	11
	17	8
	20	5
	28	19
	31	16

λ TAURI.

Sept.	1	14
	5	13
	9	12
	13	11
	17	9
	21	8
	25	7
	29	6

R CANIS MAJ.

	d	h
Sept.	5	15
	6	18
	13	14
	14	17
	21	13
	22	16
	29	11
	30	15
Oct.	1	18
	8	13
	9	17
	16	12
	17	16
	25	15
	26	18

S CANCRI.

Sept.	16	16
Oct.	5	15
	24	14

δ LIBRÆ.

Sept.	3	7
	10	7
	17	6
	24	6

U CORONÆ.

Sept.	3	10
	10	8
	17	6
	20	17
	27	14
Oct.	4	12
	11	10
	28	8
	21	18
	28	16

U OPHIUCHI.

	d	h
Sept.	3	14
	4	10
	5	6
	9	11
	10	7
	14	12
	15	8
	19	13
	20	9
	21	5
	24	13
	25	9
	26	6
	30	10
Oct.	1	6
	5	11
	6	7
	11	8
	16	9
	17	5
	21	9
	22	6
	26	10
	27	6

Z HERCULIS.

Minima after star has set for observation in the U. S.

Y CYGNI.

Even Epochs.

	d	h
Sept.	1	11
	4	11
	7	11
	10	11
	13	11

Y CYGNI Cont.

Even Epochs.

	d	h
Sept.	16	11
	19	11
	22	10
	25	10
	28	10
Oct.	1	10
	4	10
	7	10
	10	10
	13	10
	16	10
	19	10
	22	10
	25	10
	28	9
	31	9

Odd Epochs.

Sept.	2	15
	5	14
	8	14
	11	14
	14	14
	17	14
	20	14
	23	14
	26	14
	29	14
Oct.	2	14
	5	14
	8	13
	11	13
	14	13
	17	13
	20	13
	23	13
	26	13
	29	13

Maxima and Minima of Long Period Variables.

MAXIMA.

1895 September.

Date.	No.	Star.
2	494	R Sculptoris.
3	5338	U Bootis.
3	6132	R Ophiuchi.
5	4948	R Canes Ven.
6	7431	S Delphini.
10	7577	X Capricorni.
12	7609	T Cephei.
15	4377	T Virginis.
24	5237	R Bootis.
25	7560	R Vulpeculæ.
26	6512	T Herculis.
26	7450	V Aquarii.
27	7783	RU Cygni.

1895 October.

7	8068	S Lacertæ.
8	906	R Trianguli.
8	4492	Y Virginis.
9	3060	U Cancri.
11	3567	V Leonis.
11	6921	S Sagittari.
13	2583	L Puppis.

MAXIMA CONT.

1895 October.

Date.	No.	Star.
13	3994	S Leonis.
15	4816	V Virginis.
15	5677	R Serpentis.
18	114	S Ceti.
19	1761	R Orionis.
20	4521	R Virginis.
20	8324	V Cassiopeæ.
21	782	R Arietis.
22	5830	R Scorpii.
27	3170	S Hydræ.
28	4557	S Ursæ Maj.
29	2691	T Canis min.
29	7468	T Aquarii.
31	7733	V Capricorni.

MINIMA.

1895 September.

2:	2976	V Cancri.
8	243	U Cassiopeæ.
8:	513	R Piscium.
9:	432	S Cassiopeæ.

MINIMA CONT.

1895 September.

Date.	No.	Star.
14	1717	V Tauri.
15:	7085	RT Cygni.
17	4596	U Virginis.
21	4511	T Ursæ Maj.
21	7428	V Cygni.
24	3637	S Cancri.
28	3493	R Leonis.

1895 October.

1:	715	S Arietis.
5:	1577	R Tauri.
9:	5494	S Libræ.
10:	6207	Z Ophiuchi.
12	845	R Ceti.
14	5955	R Draconis.
15:	2100	U Orionis.
16	5583	X Libræ.
16	7242	S Aquilæ.
20	6849	R Aquilæ.
26	7754	W Cygni.
28	1574	W Tauri.
29:	6044	S Herculis.

A colon after the date indicates doubt.

The authorities for the above are the tables of Chandler and Yendell published in the *Astronomical Journal*, except that the Algol stars for October are taken from Dr. Hartwig's ephemeris in the *Vierteljahrsschrift*. J. A. PARKHURST.

Marengo, Ill., 1895, Aug. 3.

Occultations Visible at Washington.

Date 1895.	Star's Name.	Magnitude.	IMMERSION Washington M. T. h m	IMMERSION Angle from N pt. °	EMERSION Washington M. T. h m	EMERSION Angle from N pt. °	Duration. h m
Sept. 2	ι Aquarii	4.4	6 54	19	7 42	294	0 48
8	B.A.C. 782	7 0	9 45	98	10 33	202	0 48
9	7 Tauri	6.0	16 14	9	17 5	203	0 51
12	49 Aurigæ	5.7	17 7	64	18 20	302	1 13
15	8 Leonis	5.7	16 49	63	17 31	340	0 42
23	τ Scorpii	3.2	8 13	108	9 17	253	1 4
26	B.A.C. 6666	5.8	8 47	96	9 56	217	1 9
28	B.A.C. 7325	6.9	5 40	42	7 0	270	1 20
28	26 Capricorni	7.0	7 26	111	8 20	184	0 54
30	64 Aquarii	6 9	7 29	66	8 52	219	1 23
Oct. 3	62 Piscium	6.0	8 39	61	9 55	231	1 17
8	W. IV, 1421	6.0	13 18	45	14 27	286	1 9
10	W. VI, 1656	8.2	10 31	45	11 9	314	0 38
10	47 Geminorum	6 0	13 44	32	14 19	332	0 35
14	*c* Leonis	5.3	15 6	117	16 1	296	0 56
26	γ Capricorni	3.7	7 0	57	8 27	228	1 27
26	B.A.C. 7558	8.0	10 27	77	11 31	213	1 4
27	54 Aquarii	7.0	8 48	72	10 3	207	1 15
28	81 Aquarii	6 6	2 26	57	3 29	251	1 3

Observed Maxima and Minima of Long Period Variables.

No.	Star.	Observations. Begin.	End.	No.	Phase.	Date.	Mag.	Observer.
678	U Persei.	1894 Nov. 15	1895 May 26	25	Max.	1895 Mar. 18	7.6	J. A. Parkhurst.
1981	SCamelopard	1894 Nov. 15	1895 June 13	22	Max.	1895 Mar. 8	8.1	J. A. Parkhurst.
"	" "	1894 Dec. 3	1895 May 27	38	Max.	1895 Feb. 3		W. E. Sperra.
2258	V Aurigæ.	1894 Nov 20	1895 June 13	23	Min.	1895 Mar. 17	11.5	J. A. Parkhurst.
2815	U Geminorum.	1895 June 13	1895 June 20	4	Max.	1895 June 14 ±	9 ±	W. Dearden.
3825	R Urs. Maj.	1895 Mar. 24	1895 July 30	30	Max.	1895 June 2	7.1	W. E. Sperra.
4511	T " "	1895 Mar. 16	1895 June 22	25	Max.	1895 Apr. 30	8.0	W. E. Sperra.
4521	R Virginis.	1895 Apr. 17	1895 June 27	19	Max.	1895 May 28.5	6.9	W. E. Sperra.
4847	S "	1895 Apr. 16	1895 July 16	25	Max.	1895 May 21.5	6.4	W. E. Sperra.
5157	S Bootis.	1895 Apr. 29	1895 Aug. 5	10	Min.	1895 July 2	12.7	J. A. Parkhurst.
5190	R Camelopard	1894 Nov. 20	1895 May 20	19	Min.	1895 Mar. 16	12.5	J. A. Parkhurst.
"	" "	1895 Jan. 11	1895 May 17	12	Min.	1895 Mar. 19		W. Dearden.
5338	U Bootis.	1895 Apr. 28	1895 June 21	8	Min.	1895 May 14	12.0	J. A. Parkhurst.
7085	RT Cygni.	1895 May 27	1895 Aug. 1	27	Max.	1895 July 15.0	6.9	W. E. Sperra.
7118	X Aquilæ.	1895 June 17	1895 July 30	10	Max.	1895 July 6		W. E. Sperra.
"	" "	1895 May 26	1895 Aug. 5	7	Max.	1895 July 2	9.0	J. A. Parkhurst.
8324	V Cassiopeæ.	1895 Feb. 8	1895 Aug. 8	19	Min.	1895 July 5	12.6	J. A. Parkhurst.

Comet 1884 II, Barnard.—This comet has not yet been re-discovered, but its position is becoming more favorable. We have no ephemeris extending beyond Aug. 22, when the R. A. of the comet should be somewhere between $2^h\ 30^m$ and $3^h\ 1^m$ and the declination between 14° and 18° north. Professor L. Swift observed a nebulous object on the night of June 29 in R. A. $1^h\ 20^m$ and Decl. $+2°\ 55'$ which was missing from that position on July 4. This object has not since been seen. It was not quite near enough to the path of Barnard's comet to be identified with the latter.

Phases and Aspects of the Moon.

			Central Time.		
		d	h	m	
Apogee	Sept.	3	3	18	P. M.
Full Moon	"	3	11	55	"
Last Quarter	"	11	10	51	"
Perigee	"	18	1	12	A. M.
New Moon	"	18	2	55	P. M.
First Quarter	"	25	12	23	"
Apogee	"	30	8	12	"
Full Moon	Oct.	3	4	48	"
Last Quarter	"	11	8	34	A. M.
Perigee	"	16	10	12	"
New Moon	"	18	12	10	"
First Quarter	"	25	5	4	"
Apogee	"	28	9	48	"

Orbit of Comet 1892 III (Holmes).—Mr. H. F. Zwiers, of Leiden, has recently completed a definitive determination of the orbit of Holmes' comet. From about 600 observations he obtains the following elements, with the probable errors indicated by the numbers after the ± signs.

EPOCH AND OSCULATION 1892, NOV. 4.0 GREENWICH M. T.

M_0	= 73841″.99	± 42″.05
π	= 345° 57′ 25″.93	± 92 .54
ω	= 14 15 51 .95	± 88 .38
υ	= 331 41 33 .98	± 27 .43
i	= 20 47 16 .33	± 5 .74
φ	= 24 10 45 .97	± 11 .21
e	= 0.4095956	± 0.0000496
μ	= 514″ 0399965	± 0″.1448706
log a	= 0.5593398	± 0 .0000816
T_1	= 1892 June 13.349719	± 0d.091457
T_2	= 1899 May 9.554	± 0 .718
Period	= 2521d.205	± 0 .712

Mr. Zwiers has carried forward the elements, allowing for the perturbations of the comet by Mars, Jupiter and Saturn to July 26, 1896, and expects to continue the work up to the time of return in 1899. The elements for 1896 are as follows:

EPOCH AND OSCULATION 1896, JULY 26.0 GREENWICH M. T.

M_0	= 776461″.726	
π	= 345° 37′ 42″.20	1892.0
υ	= 331 38 55 .89	
i	= 20 48 22 .63	
φ	= 24 12 16 .32	
μ	= 515″.9572436	
log a	= 0.5582619	

At the return in 1899 the comet will be in favorable position for observation a couple of months after it passes perihelion.

PRACTICAL SUGGESTIONS.

If you do not know, ask. It is quite probable that some one can answer and thereby many may be helped.

109. What is the thickness of the silver coating on glass specula? W.B.F.

Answer: An ordinary coating of silver on glass is between one and two

hundred thousandths of an inch thick, and if the deposit is a perfect one, will always transmit blue light.

Dr. Draper found the silver on his mirrors to be about one two hundred thousandths of an inch thick when they transmitted the blue light freely.

J. A. B.

110. Could this coating or film be made much thicker (double or triple) to advantage? If so would this be best accomplished by using the solution more concentrated, or in larger quantities? W. B. F.

Answer: The coating can be made thicker without difficulty but it is of little use to make it opaque, as it will absorb the blue or short waves, no matter how thick it is, besides which, there is a danger that the silver may deposit in unequal thickness, indeed, will always do so if the surface of the glass has not been thoroughly and equally cleaned.

This unequal thickness of silver will of course impair its optical value. A thicker deposit of silver can be obtained by using larger quantities of the chemicals, in the same amount of water, but a better way is to prepare two baths, and when the first coat has deposited, immediately immerse in the second bath. Of course the reducing solution must not be put into bath No. 2, until the mirror is ready to be placed in it. Considerable skill is necessary to second coat a mirror, for if any spot becomes dry in the interim of transferring from the first to the second bath, that spot will not silver as thick as the parts kept wet. If too long in the second bath the silver will bleach, hence it is the safer plan to lift mirror out of bath before all the silver is down. J. A. B.

111. What is the electrical method of silvering specula? It is mostly used in Germany, I believe, and is not yet perfected, being adapted to small mirrors only, the silvering being done *in vacuo*. W. B. F.

Answer: In brief the electric method of silvering is this. The mirror is placed in a horizontal position in a glass receiver. Over the mirror and very close to the surface a thin plate of silver is hung to a wire which in turn is connected to a powerful Ruhmkorff coil or other means of sending a strong current through the wire.

The air is then exhausted from the vessel and the current sent through the wires. Professor Wright uses a small piece of silver and keeps it swinging over the glass to be coated.

So far, this method is found a very difficult one for surfaces over two or three inches diameter, and is not at all suited for the general use of silvering specula for reflecting telescopes, beside which there is no difference in the silvering, except that in the case of chemically deposited silver a slight "patina" or bloom is left on the surface, and must be polished off, while in the case of the electrically deposited silver no polishing is necessary hence no microscopic scratches.

There is one advantage in electric deposition and that is, almost any metal may be deposited on glass. The writer has seen many beautiful specimens in Professor Wright's laboratory, of such metals as gold, platinum, iron, copper, etc., deposited on glass.

All the delicate mirrors made for Professor Langley have been coated with platinum by the electric process.

112. Another answer has been given to No. 105 as follows: Any form of crank, cam, or eccentric will transform rotary motion into reciprocating rectilinear motion, but to have it uniform, resort must be had to the cam. It may be

done also by employing a frame with parallel sides, the opposite inner sides being cut into racks which mesh into a pinion wheel revolving between them, and which has the cogs cut away from half the circumference plus one tooth: this will mesh into the racks alternately: it is an old device and rather clumsy, but may be useful under some conditions. P. S. Y.

113. In a book of amateur astronomy I find it stated that Paul, in his speech at Mars' Hill, quoted from Aratus' poem, the greater part of which is description of the Constellation. Will you please inform me where I can get that poem in English translation complete. B. F. B.

Answer: Replying to any inquiry for a translation of Aratus, I would recommend, as a faithful *translation* in verse, Robert Brown, Jr., published by Messrs. Longmans, Green & Co., London, 1885.

Good versifications are by Dr. John Lamb, published by J. W. Parker, London, 1848, and E. Poste, published by Messrs. Macmillan & Co., London, 1880. There are others, one by Noble, but I do not recall dates or publishers.

RICHARD H. ALLEN, Chatham, N. J.

Writing to the New York publishers by the same name as above, we find that Dr. John Lamb's versification of Aratus' poems is not among the books they act as publishers for and that Poste's edition of the same is out of print. Possibly the London publishers could furnish some or all of them.

114. Is there an indication to support the idea that the Sun, like Saturn's rings has a swifter movement near the center than at the outer surface?

C. A. B.

Answer: I do not know of any *evidence* to the effect that the central portion of the Sun has a shorter rotation period than the exterior, nor do I know of any sound demonstration that this *ought* to be the case. Nor, on the contrary, do I know of any evidence that it does not do so. C. A. Y.

115. In the Encyclopedia Brittanica, page 792, article on astronomy, R. A. Proctor quotes Sir John Herschel as follows: "The Earth is not exactly an ellipsoid of revolution. The equator itself is slightly elliptic, the longer and shorter diameters being respectively 41,852,864 and 41,843,096 feet." Is this statement borne out by later calculations of the figure of the Earth? G. H.

Answer: As shown in the Memoirs of the Royal Astronomical, Vol. XXIX, p. 39, 1861, it was suspected by General Schubert and Col. A. R. Clarke that the equatorial of the Earth is not circular but elliptical. Col. Clarke's conclusion is that the equatorial diameter through the meridians 13° 58′ and 193° 58′ E. of Greenwich is *one mile* longer than the equatorial diameter at right angles to it. Young says that "some of the measurements rather indicate that the equator of the Earth is not a true circle, but an oval flattened by nearly a half mile. *General Astronomy*, page 101. We can not yet say that this ellipticity of the equator is certainly proved, but rather that it is strongly probable.

116. Is it true that the Observatory at Arequipa, Peru, was looted last winter? The papers so speak of it.

Answer: I think not. Such a report went into circulation, probably, from the fact that some self-registering instruments were left on the summit of El Misti and these were stolen. This fact is stated in Professor Pickering's last annual report, page 10.

117. What is meant by the second rotation of the Earth? G. H.

Answer: This so-called "second rotation of the Earth" is an expression (so far as we know) first used by Major General A. W. Drayson F. R. A. S., which he claims is his discovery. Briefly, in his own words, it is as follows:—"The movement of the Earth hitherto vaguely and incorrectly described as a conical movement of the axis around the pole of the ecliptic as a center, proves to be a second rotation of the Earth, which causes the two half-axes of the Earth to describe cones during about 31,600 years The poles of the second rotation are now 29° 25′ 47″ from the poles of daily rotation, and hence, under present conditions, there would be a variation of 12° in the extent of the Arctic circles during such second rotation."—*The New Science Review*, Vol. I, No I, page 7. Mathematical astronomers are free to say that there is no such movement of the Earth as that described by General Drayson. The discussion of the topic we have seen by himself, we must say, is extremely weak in the use of mathematics.

118. How are eclipses of the Sun and Moon projected? G. H.

Answer: It would require too much space to go into the details of a projection of an eclipse to be of use to our querist. Loomis Practical Astronomy is an inexpensive book, and, in it are given illustrative examples and figures which will serve as an easy guide for this kind of work.

119. Where are catalogues of stars and nebulæ obtainable? G. H.

Answer: That will depend on what particular catalogues are wanted.

120. Are all the peculiar formations on the Moon's surface explained by a former state of volcanic activity?

Answer: Astronomers are not agreed that *all* the surface markings on the Moon can be explained by volcanic action. Those who believe that the volcanic theory accounts for the so-called crater formations with central cones, are not satisfied with such an explanation for the origin of the walled or rampart plains. They confess that the origin of these features and some others are beyond their explanation. See the *Moon* by Nasmyth and Carpenter, page 133. Also Neison's excellent book on the same theme.

GENERAL NOTES.

Attention is called to the beginning of the new volume of this publication. A large number of subscriptions are due if continuance is desired If our patrons have not already done so, will *every one* please notify us promptly about continuance. We much prefer payment in advance.

Only twenty sets of the *Sidereal Messenger* remain. Wishing to dispose of them soon we have made one more reduction in price. This extremely low price of $12 for ten volumes will not again be reduced.

To the number of ten we will give one dollar each for as many copies of the December number (1894) of *Astronomy and Astro-Physics* if returned to us within sixty days in good condition. The three volumes of this publication, in pamphlet form, are still offered for $10. Single volumes covering either the years 1892, 1893, can be had for $4 each. The Volume for 1894 is partly out of print.

We print in this number Fourier's celebrated eulogy on Laplace. This classic historical account of the life and work of the greatest of all astronomers is now very rare and not easy of access, and hence we feel confident that our readers will be grateful to Dr. See for the present translation. A just appreciation of the profound discoveries in the development of astronomy will be helpful in building up the subject of physical astronomy in the United States. It is desirable that beginners should perceive what discoveries are really difficult and of enduring importance, and that we should not rank all discoveries as great which go under that name. We do well also to remember that while large sums of money, big telescopes and elaborate apparatus, when properly used, are useful aids to astronomy, they do not of themselves make science.

Laplace was never director of an Observatory, nor had he any large telescope at his disposal, and yet he made more really enduring discoveries, discoveries of the profoundest character, than any other man that ever lived, save possibly Newton. In order to go deeply into the science students must take up the mathematical side of the subject—it is the great mathematical astronomers who have rendered the science so luminous in all past ages. The interest of the country in physical astronomy has been much stimulated during the last two years, and we feel sure that every American who has any pride in the science of his country will be glad to see the good work go on.

School of Astronomy at the University of Chicago.—The graduate School of Astronomy at the University of Chicago is in a very flourishing condition. During the summer quarter Dr. See is lecturing on the *Theory of Orbits*, and on the *Mathematical Theory of the Heat of the Sun*, and conducting a seminar for the investigation of special topics. The following persons are in attendance:

Professor James N. Hart, of Maine State College; Professor S. J. Cunningham, of Swarthmore College; Professor C. E. Furness, of Vassar College; Professor F. E. Harpham, of Smith College; Professor Duane Studley, of Wabash College; Professor T. M. Blakeslee, of Des Moines College; Professor Eric Doolittle, of the Iowa State University; Professor C. F. Arnold, of the Ohio State University; and Mr. F. R. Moulton, of Albion College.

The Editor of POPULAR ASTRONOMY was much pleased, on a recent visit to Chicago, to find some of his old pupils working with great enthusiasm in the higher branches of mathematical astronomy. The work which Chicago University has undertaken is full of promise for the future of American astronomy. Nothing is more needed in this country than a high grade school of physical astronomy, and Dr. See deserves the thanks of every friend of real science for the way he has developed the department.

The courses for the coming year include: Theory of the Attractions and Figures of the Planets; Gauss' Method of Determining Secular Variations; History of Astronomy: Introduction to Physical Astronomy; Spherical Harmonics; Theory of Orbits; Theory of Probability; Ephemerides; Astrophysical Research; and General Astronomy.

Ceres, Pallas, Juno and Vesta are the first four planetoids of the group between Mars and Jupiter, and they are numbered in catalogues in the order given above, 1, 2, 3, 4, because this was the order of discovery in the 1801, 1802, 1804 and 1807 respectively. The time of revolution of each is well known, and is in years, 4.60, 4.61, 4.36 and 3.63. But to determine the diameter

of these small bodies is a much more difficult problem. This will readily be understood if we remember that an object at the great distance of Ceres, a tenth of a second of arc corresponds to 125 miles. The instruments used in the times of Herschel and Lamont were not good enough for such delicate work. The diameters of these planetoids in Chamber's Handbook of Astronomy on the authority of Goddard and Hind are as follows:

Ceres.....196 miles.
Pallas.....171 miles.
Juno.....124 miles.
Vesta.....214 miles.

In 1894, E. E. Barnard, by the aid of the 36 inch of the Lick Observatory carefully measured the diameters of these bodies with the following results:

Ceres.....520 miles.
Pallas.....304 miles.
Vesta.....241 miles.

A full account of his work will be found in *Astronomy and Astro-Physics*, May number, 1894, and in No. 9, Vol. 54 of the *Monthly Notices* of the Roya Astronomical Society, page 571.

July 23 Mr. Barnard writes as follows: "I have made, on two nights, measures of the diameter of Juno. They make it the smallest of the four. It is not far from 130 miles in diameter." Teachers of astronomy correct your text-books. This is good authority.

Visitors at Goodsell Observatory.—On August 9, Professor George C. Comstock, Director of Washburn Observatory and Professor F. P. Leavenworth, in charge of Practical Astronomy at the University of Minnesota, visited Goodsell Observatory, and while present they determined each his personal equation by the aid of the Eastman Personal Equation Machine belonging to the Observatory. This little piece of work was important to these astronomers just now, because they have recently been determining the longitude between the Washburn Observatory at Madison and the site for the new Observatory in process of erection on the University campus at Minneapolis. While the observations for these personal equations have not yet been fully reduced, it was determined that the difference between them was about 8/100 of a second. The observations of both astronomers are slow on true time.

The visit of Professors Comstock and Leavenworth, though short, was exceedingly pleasant and enjoyable, giving occasion to compare notes on current astronomical themes.

Eclipses of the Sun, Aug. 20 and Sept. 18, 1895—A partial eclipse of the Sun will occur on Aug. 20, beginning at $6^h\ 4^m$ A. M., and ending at $8^h\ 15^m$ A. M. Central time. It will be visible only in the western part of Asia, the eastern part of Europe and the north polar regions. At greatest eclipse in Siberia a little more than one-fourth of the Sun's disc will be obscured.

Another partial eclipse of the Sun will occur Sept. 18 beginning at $12^h\ 39^m$ P. M., and ending at $4^h\ 29^m$ P. M., Central time. It will be visible only in the South Pacific and Antarctic Oceans.

Total Eclipse of the Moon Sept. 3, 1895.—A total eclipse of the Moon will be visible in the United States and generally throughout North and South America on Tuesday night Sept. 3. The beginning will also be visible in

the western portions of Europe and Africa and the ending in the Pacific Ocean. The Moon begins to enter the umbra of the Earth's shadow at $9^h\ 59^m.9$ P. M., and leaves it at $1^h\ 53^m.9$ A. M. Central time, so that the hours will be very favorable for observation in the United States.

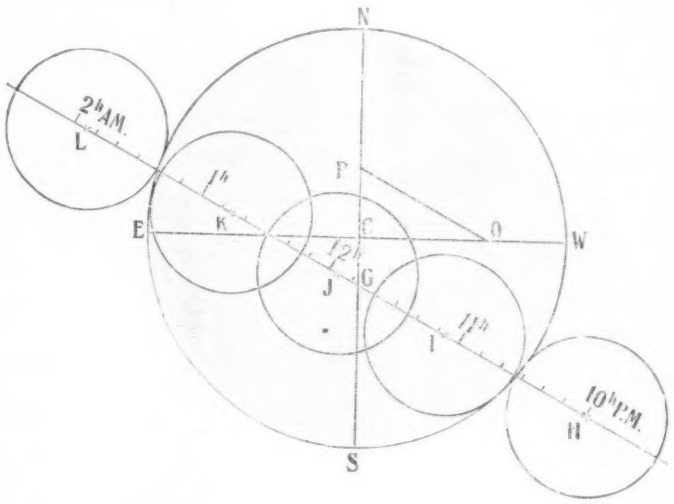


DIAGRAM OF THE LUNAR ECLIPSE, SEPT. 3, 1895.

The accompanying diagram will indicate to the reader the course of the Moon through the Earth's shadow. A cross-section of the latter at the Moon's distance is represented by the large shaded circle NESW. The penumbra of the shadow is not represented since it does not produce a very noticeable darkening of the Moon's surface. At $9^h\ 59^m.9$ the Moon's center will be at *H* and its north east edge or limb will just touch the dark part of the shadow; at $11^h\ 6^m$ it will be at *I*, completely immersed in the shadow; total eclipse begins. At $11^h\ 57^m$ the Moon will be at *J*, half way through the shadow; middle of eclipse. At $12^h\ 47^m$ the Moon at *K* touches the edge of the shadow and begins to emerge; total eclipse ends, and at $1^h\ 54^m$, with its center at *L* the Moon leaves the shadow, only a faint penumbral shading remaining near the point of last contact.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of conjunction in right ascension, Sept. 3, $17^h\ 47^m\ 46^s.6$.

Sun's right ascension	$10^h\ 51^m\ 28^s.07$	Hourly motion	$9^s.04$
Moon's right ascension	$22^h\ 51^m\ 28^s.07$	Hourly motion	$105^s.82$
Sun's declination	$7^\circ\ 17'\ 2''.5$ N.	Hourly motion	$0'\ 55''.3$ S.
Moon's declination	$7\ 25\ 54\ .8$ S.	Hourly motion	$13\ 44\ .6$ N.
Sun's equa. hor. parallax.	$8\ .5$	Sun's true semi-diam.	$15\ 52\ .1$
Moon's " " "	$53'\ 58\ .4$	Moon's " "	$14\ 41\ .8$

TIMES OF THE PHASES.

	Greenwich M. T.			Central Standard T.		
		h	m		h	m
Moon enters penumbra	Sept. 3	14	47.9	Sept. 3	8	47.9 P. M.
Moon enters shadow		15	59.9		9	59 9 "
Total eclipse begins		17	6.4		11	6.4 "
Middle of eclipse		17	57.0		11	57.0 "
Total eclipse ends		18	47.5	Sept. 4	12	47.5 A. M.
Moon leaves shadow		19	53.9		1	53.9 "
Moon leaves penumbra		21	6.1		3	6.1 "

Numbering of recently discovered Asteroids.—The asteroids discovered between Nov. 1, 1894 and March 21, 1895, have been numbered or identified with previously discovered planets, as follows:

	Discovered	By	At	Number
BD	Nov. 1	Wolf,	Heidelberg,	orbit unknown
BE	Nov. 1	"	"	(391)
BF	Nov. 4	"	"	(392)
BG	Nov. 4	"	"	(393)
BH	Nov. 19	Borrelly	Marseilles,	(394)
BI	Nov. 24	Charlois,	Nice,	(369) *Aeria*
BK	Nov. 30	"	"	(395)
BL	Dec. 1	"	"	(396)
BM	Dec. 19	"	"	(397)
BN	Dec. 28	"	"	(398)
BO	Apr. 9	Roberts,	——	orbit unknown
BP	Feb. 23	Wolf,	Heidelberg,	(399)
BQ	Feb. 23	"	"	orbit unknown
BR	Feb. 25	"	"	(379)
BS	Feb. 25	"	"	(333) *Badenia*
BT	Mar. 16	"	"	(401)
BU	Mar. 15	Charlois,	Nice,	(400)
BV	Mar. 15	Wolf,	Heidelberg,	(203) *Pompeia*
BW	Mar. 21	Charlois,	Nice,	probably (402)

Mr. Berberich suspects that a more recently discovered asteroid, BX, may prove to be the long lost (156) *Xanthippe*.

No. 392 has been named *Wilhelmina* and No. 401 *Ottilia*.

Astronomer Barnard goes to the Yerkes Observatory.—The trouble between Director Holden, of the Lick Obsevatory, and E. E. Barnard, causing strained relations between them for some time past, recently culminated in the latter's resignation of his position as astronomer at the Lick Observatory to take effect October 1st of this year. The authorities at Yerkes Observatory were quick to see their opportunity and as ready to act in electing Mr. Barnard to the staff of the great Observatory now in process of erection at Geneva Lake Wisconsin.

In such cities as San Francisco and New York, leading daily papers have recently had much to say about the condition of things at Mount Hamilton, and the thorough sifting and ventillation that has been going on for past weeks can but result in good there, although it may take some time to purify that mountain air.

One of the worst things about the trouble that we have noticed, is, the effort on the part of Mr. Barnard's enemies to degrade the character of his scientific work. That any astronomer may sometimes make mistakes is only natural; but when such accidental errors are paraded with the apparent intent to lessen his reputation as an astronomer, such a course is foolish and utterly mean on the part of anyone. Any astronomer who has knowledge of the facts, very well

knows that Mr. Barnard's record, as an astronomer, is not only above question of that kind, but also that it stands exceptionally high the world over. Mr. Barnard does not need encomiums from us. He has made his record in a more substantial way. The Yerkes Observatory is to be congratulated in securing Mr. Barnard for a place on its working staff.

Configuration of the Planets and the "Star of Bethlehem."—We notice briefly one or two other things that have claimed the attention of popular readers during the summer months. One is the prediction of one Dr. Ellis, that on Good Friday, April 12, 1895, the configuration of the planets was the same exactly as when the crucifixion of Christ took place more than 1800 years ago. Any school boy who can find the least common multiple of numbers can disprove that. It must be evident to any one, that if the planets have, at any given time, a particular relation to one another respecting place in the sky, that same relation will again occur when every one has revolved around the Sun some *whole* number of times. Hence find the least common multiple of the periods of all the planets and that number in days, years or months will be roughly the interval in time between two successive like configurations of the planets. Try it and see if eighteen centuries will satisfy these simple conditions.

The other matter is about the so-called "Star of Bethlehem." One esteemed correspondent is certainly wrong in supposing that the planet Mars could have fulfilled the conditions given in the second chapter of Matthew. It is not possible to determine a particular spot, by the motion of an ordinary star or planet going before as a guide until it stands over that particular spot and so designates that place from others surrounding it. The star or planet is too far away. Even the Moon is, too, to serve for any such purpose. It is more probable to suppose that the so-called "Star of the East" or the "Star of Bethlehem" was a miraculous phenomenon for the sole purpose indicated in the account given in Matthew. If this be true, it was not a star at all in the astronomical meaning of the word, but only the appearance of one.

"The Signals from Mars."—A few days after the publication of our last number, articles were noticed in such papers as the *New York Herald*, giving account of the so-called "Signals from Mars," the canals on the surface of the planet, and also the latest astronomical speculation, that some of the features on its surface are so made as to spell out the name of *The Almighty* in Hebrew letters. And all this is charged to the account of astronomers of the present time. This is truly an age of most wonderful discovery! We cannot learn what astronomer it is that has made these great discoveries. But whoever it is, that fortunate being has surely found the Hebrew, astronomical key to the history, and long resting place of the ten lost tribes of Israel. Think of it! Donnelly's Baconian key to Shakespeare is childish by the side of such modern scientific wonders.

It is a burning shame that such nonsense finds place in our best and greatest daily papers.

Popularizing Astronomy.—Our genial friend, Alfred Bicknell, of Boston, will pardon us for publishing a part of a private letter recently received from him. The sentiment is ours and well expressed as follows:—

For years I have believed that if scientists and amateurs would talk to the people in a conversational way, setting forth the main facts in astronomy,

that great good would come of it. It would in time bring about a public interest and demand for systematic teaching in all our high schools, with suitable instruments so that every boy and girl graduating from our high schools would have a fairly clear idea of what they were looking at when they saw the stars. Now they do not. The great mass of our men and women are densely ignorant of all these things. They know all about base ball, and other "sports," but are the veriest children in this grand study. I wish it were otherwise. Our scientists might unbend a little, and give some of their stores of knowledge to the ignorant and unthinking, with no loss to themselves, and so help along a much needed missionary work. I do not expect to live to see this "consummation devoutly to be wished," but I firmly believe that mankind will never be brought to realize the attributes of the Great Creator, in so far as mortals can comprehend them, until they possess a better knowledge of His works than they now do.

Dr. Robert's Photographs.—The publishers of *Knowledge* have announced that Dr. Isaac Roberts, F. R. S., has kindly offered to continue in *Knowledge* his exquisite selection of photographs of stars, star-clusters and nebulæ, and the first photograph will appear very soon. The series is intended to be in continuation of Dr. Roberts' work, "A Selection of Photographs of Stars, Star-Clusters and Nebulæ," recently published, and which has, admissibly, contributed largely to the extension of the knowledge of astronomical phenomena.

J. A. Brashear of Allegheny is at present very busy with optical work from patrons at home and abroad. Three state universities have contracted for object-glasses. One German University has ordered two 16-inch photographic doublets, and the Smithsonian Institution has ordered a 6-inch glass with photographic corrector. Four large spectroscopes and other small work are in hand so that the new large shops are already full of business.

E. E. Barnard to be at Yerkes Observatory —After Oct. 1st, 1895, my address will be Yerkes Observatory, Lake Geneva, Wisconsin. I have resigned my place at Lick Observatory to accept a position in connection with the 40-inch Yerkes telescope at the Yerkes Observatory. E. E. BARNARD.

1895, July 10.

Professor C. L. Doolittle, for many years in charge of the Department of Mathematics and Astronomy, Lehigh University, Bethlehem, Pa. has accepted a call to the University of Pennsylvania, as Director of the new Observatory and Dean of the Scientific Faculty. The new Observatory will be located about five miles west of the Philadelphia Court House. Its equipment will consist of an 18-inch equatorial, 4-inch zenith telescope, 4-inch meridian circle, and 3-inch prism transit.

The contract for the entire equipment has been awarded to Warner & Swasey. J. A. Brashear will furnish all the optical parts and the spectroscope.

Professor Leavenworth of University of Minnesota, is to be congratulated on having secured a telescope with a Brashear 10½-inch objective. This instrument will be a combination visual and photographic.

The contract for the equatorial mounting has been awarded to Warner & Swasey, who expect to have the telescope in position in the early autumn.

The State University at Columbus, Ohio, has ordered from Warner & Swasey one of their most improved equatorial telescopes of 12 inch aperture with Brashear objective. Brashear also makes the spectroscope.